Universidade de Aveiro Departamento de Biologia
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Rafael Batista de Mendonça

Community ecology of anurans and lizards in a phytophysionomical gradient of the Cerrado biodiversity hotspot

Ecologia de comunidades de anuros e lagartos em um gradiente fitofisionômico do *hotspot* de biodiversidade do Cerrado

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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Ecologia Aplicada, realizada sob a orientação científica do Professor Doutor Amadeu Mortágua Velho da Maia Soares, Professor Catedrático do Departamento de Biologia da Universidade de Aveiro e co-orientação do Prof. Doutor Eduardo Manuel Silva Loureiro Alves Ferreira, Professor Auxiliar Convidado do Departamento de Biologia da Universidade de Aveiro.

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palavras-chave

riqueza específica; Anura; Squamata; distribuição local; fitofisionomias; APA Serra do Lajeado; Cerrado hotspot; modelação ecológica; GLMM; conservação da biodiversidade.

resumo

Atualmente o bioma Cerrado é um dos ecossistemas mais ameaçados do mundo, sendo classificado como um dos 34 *hotspots* de biodiversidade e também considerada a savana com maior diversidade de espécies do mundo. Nas ultimas décadas, devido ao investimento econômico, principalmente para atividades agrícolas e agropecuarias, o bioma tem perdido cerca da metade de sua área nativa. De acordo com algumas estimativas, se o atual modelo de exploração for mantido, até 2030 não existirão áreas naturais de Cerrado. Atualmente existem menos de 9% de áreas protegidas e considerando a alta taxa de diversidade e endemismos, aliado a carência de estudos, principalmente na região norte e nordeste do Cerrado, os impactos para esse bioma impulsionam perdas de patrimônio genético assim como a extinção de espécies, além de favorecer a perda dos serviços ambientais nesse ecossistema. Assim, é de suma importância conhecer a real composição de espécies e sua relação com seu habitat, principalmente em áreas não suficientemente amostradas, afim de fornecer subsídios para a conservação das espécies desse bioma. Sendo assim esse trabalho visou, através de um inventário de anuros e lagartos usando armadilhas de queda com redes de deriva, conhecer a riqueza e distribuição local de espécies em um gradiente fitofisionômico de Cerrado, procurando perceber qual a dinâmica de uso das especies dentro do gradiente, bem como os efeitos das variáveis ambientais através da modelação ecológica de uma espécie modelo (GLMM). Durante todo o estudo foram efetuados 408 registos de anuros representados por 15 espécies e 937 registos de lagartos representados por 14 espécies. O gradiente fitofisionômico apresentou uma elevada riqueza de espécies de anuros e lagartos com maior riqueza específica rarefeita de espécies na fitofisionomia de campo sujo (anuros) e tabocal (lagartos). As assembleias de anuros e lagartos incluíram: espécies com ampla distribuição geográfica; espécies compartilhas com os biomas Amazônia, Caatinga, Mata Atlantica e Chaco; bem como espécies endêmicas do Cerrado. A dinâmica de uso do habitat dentro do gradiente pareceu estar fortemente correlacionada com a dicotomia sazonal onde espécies transitaram em diferentes ambientes de acordo com as mudanças sazonais. Após amostragem da comunidade de anuros e lagartos, foi escolhida a espécie mais abundante do estudo com distribuição em áreas abertas no Cerrado (*Tropidurus oreadicus*), a fim de testar através da modelagem ecológica (GLMM) o efeito de categorias de variáveis temporais e sazonais, climatológicas, meteorológicas, fitofisiónómicas e de microhabitat na distribuição local dessa espécies, onde através da geração de modelos explicativos, pode-se determinar quais as variáveis que melhor explicam a distribuição local de *T. oreadicus*. Foi amostrado um total de 536 *T. oreadicus*, com registro em todas as fitofisionomias. O modelo que melhor explicou a variação na distribuição de *T. oreadicus* incluiu variáveis sazonais (explicando 9,7% da variação nos dados da distribuição), seguidos das variáveis meteorológicas (9,2% da variação) variáveis climáticas (7,8% da variação), variáveis relacionadas a fitofisionomia (5,2% da variação) e de microhabitats (4% da variação). Os resultados desse estudo indicam que a variação na distribuição local do lagarto *T. oreadicus* ocorre em resposta a diferentes conjuntos de variáveis, onde todas as categorias utilizadas tiveram peso na espécie alvo. Ainda sim, os fatores sazonalidade e meteorologia parecem explicar melhor a distribuição local da espécie. Os lagartos devem atender às suas necessidades de termorregulação para realizar atividades com relação estrita com a temperatura, precipitação e período de luz solar. Devido ao grave estado atual de alteração de habitat no bioma Cerrado, é imprescindível manter a diversidade de vegetação a fim de manter as comunidades herpetológicas e seus serviços ambientais.

keywords

species richness; Anura; Squamata; local distribution; phytophysiognomies; APA Serra do Lajeado; Cerrado hotspot; ecological modeling; GLMM, conservation of biodiversity.

abstract

Currently the Cerrado biome is one of the most threatened ecosystems of the world, being ranked as one of the 34 biodiversity hotspots and also classified as the Savannah with the highest species diversity in the world. In the last decades, due to economic investment mainly for agricultural and livestock production, the biome has lost about half of native area. According to some estimates, if the current exploration model is maintained, until 2030 will not exist natural areas of Cerrado. Currently, there are less than 9% of protected areas and considering the high rate of richness and endemism with the lack of studies in the North and Northeast of Savannah, the impacts to this biome promote losses of genetic heritage and extinction of species, as well as the loss of environmental services in this ecosystem. It is of utmost importance to know the species composition and their relationship with it´s habitat, especially in areas not sufficiently sampled, in order to provide subsidies for the conservation of the species in this biome. Thus, this work intends, through an inventory of anurans and lizards using pitfall traps (pitfalls with drift fences), to know the richness and local distribution of species in a phytophysionomical gradient of Cerrado, seeking to understand the dynamics of use of the species within the gradient, as well as the effects of environmental variables through the ecological modeling of a model species (GLMM). Throughout the study, the following numbers of individuals were sampled: 408 anurans from 15 species; and 937 lizards from 14 species. The phytophysionomical gradient presented a high species richness of anurans and lizards with greater rarefied species richness in the phytophysiognomy of campo sujo (anurans) and tabocal (lizards). The assemblages of frogs and lizards included: species with wide geographical distribution; species shared with the biomes Amazon, Caatinga, Atlantic forest, and Chaco; as well as endemic species of the Cerrado. The dynamics of habitat use within the gradient seemed to follow strongly the seasonal dichotomy where the species moved in different environment according to seasonal changes. After sampling of the community of frogs and lizards, we chose the most abundant species of the study with distribution in open areas in the Cerrado (*Tropidurus oreadicus*), in order to test through the ecological modeling (GLMM) the effect of several temporal and seasonal, climatological, meteorological, phytophysionomical and microhabitat categories in the local distribution of this species. Through the comparison among of explanatory models, we could determine which variables best explained the local distribution of *T. oreadicus*. We sampled a total of 536 *T. oreadicus*, with records in all physiognomies. The model that best explained the variation in distribution of *T. oreadicus* included seasonal variables (explaining 9,7% of the variation in the distribution data), followed the meteorological variables (9.2% of variation) climatic variables (7.8% of the variance), phytophysionomical variables (5.2% of variation) and microhabitat (4% of variation). The results of this study indicate that the variation on the local distribution of the lizard *T. oreadicus* are a response to different sets of variables, where all categories of variables used had an influence on the target species. Nevertheless, the seasonal and meteorological factor seem to better explain the local distribution of species. Lizards must meet their thermoregulatory needs to perform activities, with strict relation with the temperature, precipitation and sunlight period. Due to the serious actual changes in the Cerrado´s habitat, is essential to keep the diversity of vegetation to maintain the herpetological communities and their environmental services.

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Chapter I

1. Introdução Geral – Bioma Cerrado

1.1. Geografia Física e Estrutura da Paisagem

O Cerrado é o segundo maior domínio morfoclimático Neotropical cobrindo 2.036.448 Km², o que representa 23,9% da área total do Brasil, sendo superado em dimensões apenas pelo bioma Amazônico (MMA, 2011). Localizado no Planalto Central do Brasil, esse bioma está presente nos estados do Mato Grosso, Mato Grosso do Sul, Paraná, São Paulo, Minas Gerais, Goiás, Distrito Federal, Bahia, Piauí, Rondônia, Maranhão e Tocantins, além de existirem áreas disjuntas nos estados do Amapá, Rondônia, Roraima e Amazônas. Devido a sua localização central no Brasil, está em contato com o bioma da Amazônia, Mata Atlântica, Caatinga e o Pantanal formando assim áreas de transição ou ecótonos.

O Cerrado ocupa uma região com fundamental importância na distribuição dos recursos hídricos no Brasil, que dá origem às grandes regiões hidrográficas brasileiras e sul-americanas, abrangendo seis nascentes das oito grandes bacias hidrográficas brasileiras (Lima e Silva, 2007). Atualmente os recursos hídricos no Cerrado desempenham um papel fundamental para o desenvolvimento econômico do Brasil devido a alta demanda hídrica.

Segundo a classificação de Köppen o clima é Aw (tropical chuvoso) com forte variação sazonal, apresentando duas estações bem definidas: um inverno seco e um verão chuvoso (Miner, 1989). O período de escassez hídrica (seca) pode iniciar-se em maio, com duração até setembro, e a estação chuvosa no mês de outubro, com duração até o mês de abril, apresentando uma média anual de precipitação de 1500mm com variação de 750mm a 2000mm (Eiten, 1972). A temperatura média do mês mais frio é de 18º e as altitudes variam de 300m na Baixada Cuiabana (MT), a mais de 1.600m de altitude na Chapada dos Veadeiros (GO) (Ribeiro and Walter, 1998).

De uma forma geral os solos do Cerrado apresentam baixa profundidade e disponibilidade de nutrientes, elevada acidêz devida aos altos níveis de alumínio e óxidos de ferro, apresentando solos profundos e bem drenados (Reatto et al. 1998). Grande parte desta ecoregião apresenta-se dominada por latossolos bem como outras variedades de solos que, somadas à influência do fogo (Coutinho, 2002), disponibilidade de água, nutrientes e presença de alumínio, influenciam na presença de espécies lenhosas e arbóreas (Baruch at al., 1996).

O fogo é um fator de importância para o Cerrado pois influência na estrutura e na composição florística do bioma (Dezzeo et. al 2004; Coutinho, 2002). Com abundância de vegetação xerofítica, o Cerrado dispõe de espécies adaptadas ao fogo, e como exemplo dessa relação adaptativa algumas sementes dependem das queimadas para quebra de dormência. Outras espécies apresentam tegumentos que protegem das altas temperaturas promovidas pela passagem do fogo ao qual algumas espécies dependem desse fator para reproduzirem e sobreviverem (Eiten, 1972). Fatores negativos podem ser gerados pelo fogo como diminuição do estrato arbóreo e diminuição da diversidade de espécies (Silva e Bates 2002), além de promover a mortalidade de plantas jovens durante o primeiro ano (Hoffmann, 1998), como também mortalidade da fauna (Frizzo et al., 2011). Há registros de incêndios nesse bioma pelo menos desde o final do Pleistoceno (Eiten, 1972 e Miranda et al., 2002), no entanto a ocorrência atual do fogo está em grande parte atribuída a causas antrópicas ou raios (Barroso, 2000).

Apresentando uma diversidade de formas de vegetação que variam entre formações florestais, savânicas e campestres, o bioma de Cerrado é caracterizado por uma complexidade estrutural e heterogeneidade em relação à distribuição horizontal da vegetação. Ribeiro e Walter (1998) classificaram o bioma de Cerrado de acordo com sua complexidade estrutural dividindo-o em 11 fitofisionomias e 25 subtipos de vegetação. Dentre as formações florestais encontram-se as fitofisionomias de *Mata Ciliar, Mata de Galeria, Cerradão e Mata Seca;* dentre as formações savânicas o *Parque Cerrado, Palmeiral, Vereda e Cerrado sensu stricto*; para as formações campestres o *Campo Sujo, Campo Limpo e Campo Rupestre*. A diversidade de fitofisionomias pode ser explicada principalmente através da disponibilidade de água, nutrientes, teor de alumínio, ação do fogo e variações topográficas e de relevo (Coutinho 1982; Coutinho, 1978; Eiten, 1972;). Segundo Silva e Bates (2002) a maior parte do Cerrado é formado por áreas de savana, ao qual as áreas de floresta ou áreas de transição (floresta-savana) compreendem apenas 28% da área total do bioma**.**

1.2. Biodiversidade e endemismos

Historicamente, se pensava que esse bioma apresentava baixa diversidade, contendo apenas espécies generalistas, e que essa diversidade tinha maior relação com os biomas vizinhos (Vanzolini, 1976; Vitt, 1991; Silva e Sites, 1995) mas, nas últimas décadas, diversos estudos têm mostrado o contrário. Inventários realizados com elevado esforço amostral nas regiões do Cerrado têm registrado uma elevada diversidade taxonômica (Oliveira e Marquis, 2002; Colli et al. 2002, Nogueira et al 2006) além de registro para novas localidades e descrição de novas espécies (e.g. Giugliano et al., 2013; Teixeira Jr et al., 2013; Roberto et al. 2013; Carvalho e Giaretta 2013, Ribeiro-Júnior e Bertoluci, 2009).

É a savana tropical com maior diversidade de espécies no mundo (Klink e Machado, 2005) sendo atualmente conhecidas cerca de 11.627 espécies de plantas superiores ao qual 40% dessas espécies são endêmicas (Ratter et al., 1997). Para a fauna de vertebrados do Cerrado são contabilizadas 251 espécies de mamíferos (Paglia et al., 2012), 856 de aves (Silva e Santos, 2005), 267 espécies de répteis Squamata (Nogueira et al., 2011) e 209 espécies de anfíbios (Valdujo et al. 2012). Além da alta diversidade de espécies o bioma também é reconhecido por apresentar altas taxas de endemismos para diversos taxa, nos qual a percentagem pode chegar a 45%, como no caso dos anfíbios (Bastos, 2007), 20% para répteis, 11% para os mamíferos e 1,4% das aves (Silva, 1995a; Myers et al. 2000). Além do elevado endemismo, outra das explicações apresentadas para a alta diversidade de espécies contidas no Cerrado se deve ao intercâmbio de espécies com regiões adjacentes durante o período das flutuações climáticas e florísticas do Quaternário (Silva, 1995b).

1.3. Conservação do Cerrado

Devido a alta diversidade e endemismos, bem como o grau de ameaça que tem sido submetido, o bioma Cerrado foi classificado com um dos 34 *hotspots* ou pontos quentes da biodiversidade no mundo (Mittermeier et al., 2004) e também classificado como última fronteira agrícola do planeta (Klink e Machado, 2005; Borlaug, 2002) fazendo com que o bioma seja foco prioritário para conservação.

Nas últimas décadas, o bioma tem sido amplamente explorado (Kink e Machado, 2005) de modo a tornar-se atualmente o bioma com maior produtividade econômica em comparação aos outros biomas brasileiros (MMA, 2002). Essa exploração gerou impactos de forma rápida e agressiva, mesmo comparativamente ao bioma Amazônico (Ratter et al 1997), transformando áreas nativas em pastagens e culturas anuais. Atualmente o Cerrado apresenta pouco mais de 50% de áreas alteradas. (Klink and Machado 2005; Grecchi et al., 2015) com uma tendência de redução de áreas nativas de 0,7% ao ano (Brasil, 2011). A maior parte das modificações no uso da terra dentro do bioma são devido à implementação de pastagens, sendo mais de 41% utilizado para esse fim, 11% para atividades agrícolas, e quase 2% consideradas áreas urbanas, e apenas 0,07% para florestas artificiais (Klink & Machado, 2005). Dentre os inúmeros impactos podemos citar: degradação do ecossistemas, perda e fragmentação de habitat para pecuária, cultivo intensivo da soja, cana de açúcar, silvicultura; extinção de espécies, invasão biológica por espécies exóticas; poluição dos aquíferos, erosão dos solos, mineração; construção de barragens para produção de energia hidroelétrica; mudanças hidrológicas; uso indevido do fogo e alteração das frequências naturais das queimadas, desequilíbrios no ciclo do carbono e mudanças climáticas (Ratter et al., 1997; Rodrigues et al., 2005; Klink e Machado, 2005; Silvano et al., 2003).

Existem pouco mais de 8% de áreas legalmente protegidas no Cerrado, sendo 2,85% de unidades de conservação de uso integral e 5,36% de uso sustentável (MMA, 2002). Estima-se ainda que 20% das espécies endêmicas presentes no Cerrado estejam fora das áreas protegidas (Machado et al., 2004a). Também é relevante perceber que o restauro de ecossistemas savânicos no Brasil tem sido pouco utilizado como meio de garantir a conservação (Borlaug, 2002).

O conhecimento sobre a fauna e flora do Cerrado ainda é incipiente (Oliveira e Marquis, 2002) existindo muitas regiões ainda não estudadas em relação ao conhecimento básico sobre a composição faunística. Segundo Ministério do Meio Ambiente (2016) são contabilizadas 132 espécies de fauna ameaçadas no Cerrado. Considerando-se a velocidade de fragmentação e perda de habitats, aliado a carência de estudos básicos, o bioma Cerrado sofre um grave processo de perda de patrimônio genético e serviços ecossistêmicos. Caso o modelo econômico de exploração do Cerrado for mantido com as taxas atuais de desflorestação, a previsão é que até 2030 este bioma desapareça (Klink e Machado, 2005; Machado et al. 2004a).

1.4. Objetivos da tese

Dois dos grupos taxonômicos que sofrem ameaça constante relacionada a perda e fragmentação do habitat são os anfíbios e répteis (Silvano e Segalla 2005; Nomura et al. 2012). A carência de dados básicos sobre a herpetofauna no Cerrado, somado ao grau de ameaça que o bioma vem sofrendo devido ao forte avanço dos impactos, faz com que seja urgente conhecer a diversidade herpetológica e sua relação com o ambiente, à medida que existam diversas áreas ainda não amostradas principalmente na porção norte do Cerrado que compreendem aos estados do Tocantins e Maranhão. Sendo assim, a promoção de inventários de base, com esforços amostrais satisfatórios, são necessários para conhecimento da herpetofauna, fornecendo subsídios para implementação de medidas para conservação das espécies e do ecossistema. Conhecer a composição da herpetofauna e sua relação com os componentes ambientais no bioma Cerrado conhecendo a dinâmica de uso de habitat das comunidades herpetológicas são imprescindíveis para a proteção e uso adequado das áreas desse bioma. Sendo assim, esse trabalho tem como objetivos: (i) conhecer a composição e distribuição local de anuros e lagartos de solo em uma área de gradiente fitofisionómico do bioma Cerrado; (ii) compreender a dinâmica de uso do gradiente fitofisionômico de Cerrado por espécies de herpetofauna do Cerrado, procurando perceber a relação de uma espécie modelo (*Tropidurus oreadicus*) com variadas variáveis ambientais (climáticas, meteorológicas, temporal e de habitat). O primeiro objetivo será abordado no Capítulo II desta tese e o segundo objetivo será abordado no Capítulo III. Os resultados de ambos os capítulos serão discutidos de forma integrada na Discussão geral (Capítulo IV), onde estabelecerei a relação e a relevância desses resultados para a conservação da herpetofauna do Cerrado, apontando caminhos para investigação futura.

Chapter II

2. Composition and dynamics of the anuran and lizard assemblages in a phytophysionomical gradient of the Cerrado hotspot.

2.1. Abstract

Located in the Central Brazilian Plateau, the Cerrado biome is the second largest Neotropical domain, classified as the most biodiverse tropical savannah in the world, with high level of endemism. In the last decades, Cerrado has lost half of its natural area to agribusiness and if the current exploration model is maintained, this biome is expected to disappear until 2030. Baseline studies and inventories are essential to protect and conserve the cerrado biome. Due the strong seasonal dichotomy and the heterogeneity of habitats with different types of vegetation, we aim to understand the local distribution and richness of anurans and lizard within a phytophysionomical gradient of Cerrado, as well as the changes in assemblages in response to the seasonal variation. Thus, we conducted a survey of the anuran and lizard assemblages during 11 months period (2013/2014) in four vegetation types formed by savanna grassland (*campo sujo*), savanna woodland (*cerrado sensu stricto*), gallery forest (*mata de galeria*) and *tabocal* (*Guadua* sp.) We used 49 station of pitfall traps with drift fences installed in a single line crossing four phytophysiognomies. We recorded a total of 1345 specimens, from which 30% (n=480) were amphibians and 70% (n=937) were lizards. We recorded 15 anuran species and 14 lizard species. The highest species richness for anurans was in *campo sujo* (nine species) and for lizards in *tabocal* vegetation (six species). The seasonality influenced more intensely the anuran species, with 89% of the individuals being recorded during the rainy season. Records of lizards were more balanced among both seasons. In general, community of anurans and lizards appear to shift their local distribution inside the phytophysiognomies, following the seasonal changes. Despite the affinities with particular microhabitats or vegetation type, species are able to change the local distribution between phytophysiognomies, reinforcing the importance of conserving Cerrado considering its heterogeneity.

Keywords: Anuran - Squamata – Ground-dwelling species – Species Richness - Pitfalls - Seasonal changes – Campo sujo - Cerrado sensu stricto - Mata de galeria - Tabocal

2.2. Introduction

The Cerrado biome is the second largest Neotropical domain with an extension of 2 million km² corresponding to almost 24% of the total area of Brazil, only smaller than the Amazonian biome (MMA, 2011). This tropical savanna is located in the Central Brazilian Plateau (Oliveira and Marquis, 2002) with altitudes ranging from 300m to 1.600 meters bordering other biomes such as the Amazonian rainforest, Atlantic forest, Caatinga and Pantanal (Ribeiro and Walter, 1998).

The Cerrado biome has a well-defined seasonality with a dry season from May to September and a rainy season from October to April (Nimer, 1989) with 1500mm of annual average precipitation and variation between 750mm to 2000mm (Eiten, 1972). The vegetation of Cerrado biome is characterized by a structural complexity and horizontal heterogeneity due to the coexistence of forest, savanna and grassland formations, with eleven phytophysiognomies types (Ribeiro and Walter, 1998). Heterogeneous environments offer more resources which results in greater numbers of niches, supporting higher species diversity than simpler environments (Bazzaz, 1975). Transitions between phytophysiognomies can be consider as ecotonal areas that form gradients of vegetation in the Cerrado areas (Coutinho, 1978), in which turnover of species between regions can increase species richness, depending of the intensity and frequency of the changes (Connel, 1978).

Although the biodiversity of Cerrado has been undervalued, currently it is recognized as the most biodiverse tropical savannah in the world (Klink and Machado, 2005) where 209 species of amphibians (Valdujo et al., 2012) and 267 species of Squamata (Nogueira et al., 2011) are accounted. However, in recent years many species have been added to the list of Cerrado showing that many species are still unknown (Colli et al., 1998, 2003a).

In the past 40 years the economic model used to explore the Cerrado have highly impacted the environments components generating fragmentation and habitat loss. Nowadays, only 45% of the original area of the Cerrado remains (Machado et al., 2004a) and only about 8% is classified as protected area (MMA, 2012). Due to the high diversity and threats, the biome was classified as one of the 34 biodiversity hotspots (Mittermeier et al., 2004) and also classified as the last agricultural frontier (Klink and Machado, 2005; Borlaug, 2002). If the current pattern of exploitation within the Cerrado is maintained, the biome might disappear until 2030 (Klink and Machado, 2005; Machado et al., 2004).

There is a lack of baseline studies with the herpetofauna species in Cerrado. Namely, herpetofauna inventories are still required to understand the current status in Cerrado areas. Lack of basic knowledge is most evident in the north and northeast regions, where even information about the existence of preserved Cerrado areas was not compiled (Diniz-Filho et al., 2005). Understanding the local distribution, richness and behavioral patterns of anurans and lizards in Cerrado areas is important, in order to promote the best management and conservation strategies for this biome. The main objectives of this study are (1) to inventory the anurans and lizard assemblages and understand their local distribution and the species richness within a Cerrado gradient formed by four vegetation types (*campo sujo, cerrado sensu stricto, mata de galeria* and *tabocal)*; (2) and understanding the dynamics of the local distribution of anurans and lizards along the gradient and the seasons (dry and rainy), increasing the knowledge about the relationship between heterogeneity and species assemblages in the Cerrado biome.

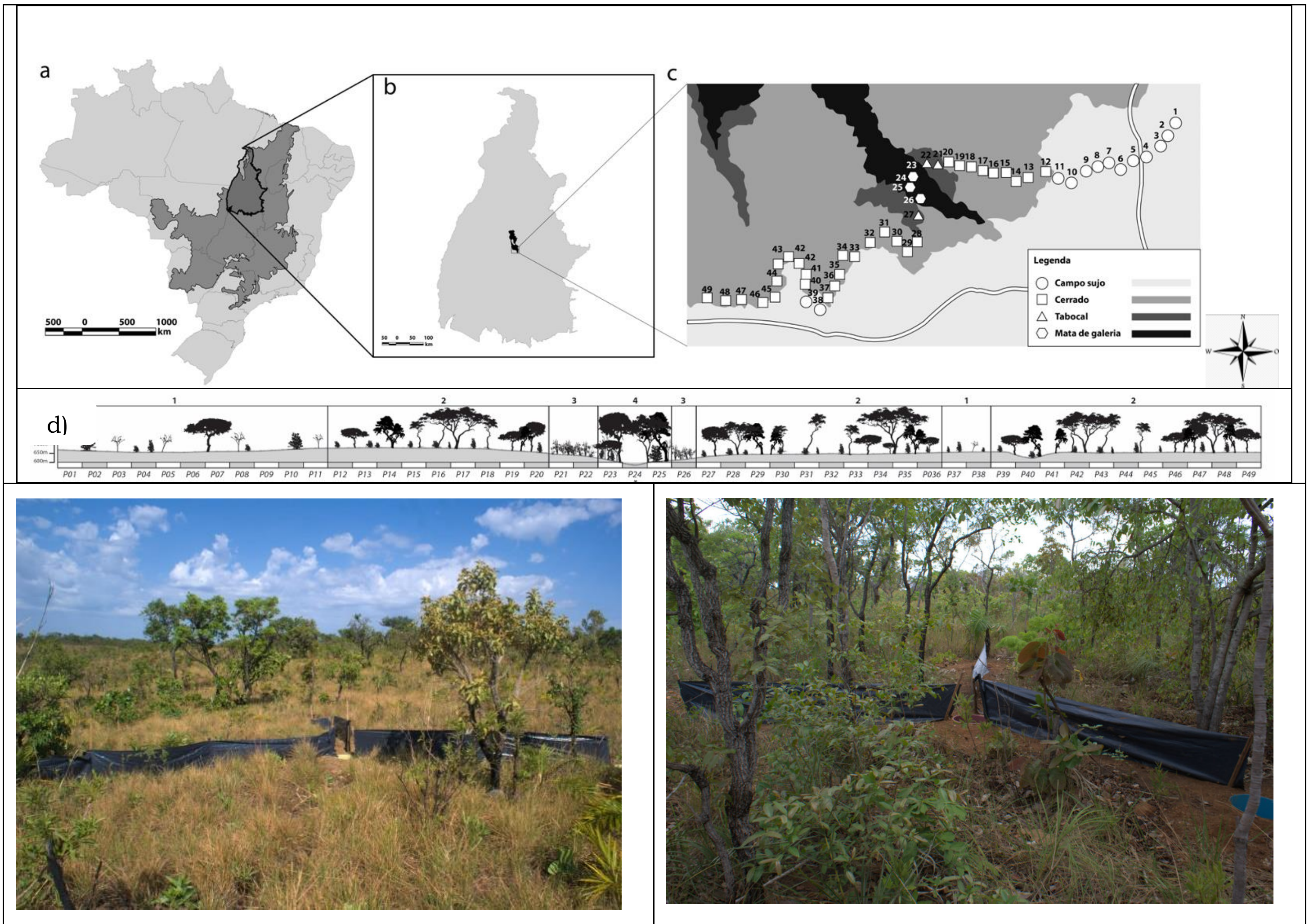
2.3. Materials and Methods

2.3.1. Study area

This study was conducted on Fazenda Ecológica (Ecotropical Institute) located in the Taquaruçu district, municipality of Palmas, State of Tocantins, Brazil (Figure I). The study area is located in the Environmental Protection Area Serra do Lajeado, classified by SNUC (National System of Conservation Unit) as a sustainable use conservation unit. Altitude in the study area ranges from 390 to 682 meters. The study area (10° 16 ' 47.33 "S/48° 9 ' 36.46" W) is part of the Cerrado domain and includes different types of vegetation (forest, savanna and grassland formations) that creates a gradient formed by three phytophysiognomies: *campo sujo* (shrubby grassland), *cerrado sensu stricto* (woody savanna), and *mata de galeria* (riparian forest vegetation). We also considered a fourth phytophysiognomy: the areas occupied by dense stands of *Guadua* sp. (*tabocal*). The study area is not pristine and evidences of anthropogenic disturbance are evident by the presence of fire, dirt roads, livestock (low scale) and ecotourism activities, one of the main factors of change in this landscape.

2.3.2. Data collection

We collected anurans and lizards using pitfall trap arrays with drift fences. We installed 49 sampling station of pitfall traps arranged in line, 50m from each other, forming a transect of 2,5 kilometres crossing the vegetation gradient formed by *campo sujo*, *cerrado sensu stricto*, *mata de galeria* and *tabocal.* The transect line of pitfall traps was composed by 30 stations in *cerrado sensu stricto*, 13 in c*ampo sujo*, three in *mata de galeria* and three in *tabocal.* (Figure I). Each sampling station was composed by four 60-litre buckets (pitfalls) buried with the opening at ground level, distributed in "Y" shape (angle of 120°) arranged 5 meters from each other and linked by drift fences with 50cm in height (Nogueira et al. 2005). In order to avoid death of individuals inside the pitfall traps, we left leaf litter inside the buckets to provide shelter and protect animals from excessive insolation during the dry season. All the buckets were drilled in the bottom to avoid the accumulation of water during the rainy season.



e) *Campo sujo* (shrubby grassland)

f) *Cerrado sensu stricto* (woody savanna)

g) *Tabocal* (Guadua sp.)

h) *Mata de galeria* (riparian forest)

Figure I. a) Brazilian Cerrado hotspot; Tocantins. b) State of Tocantins with the Environmental Protection Area Serra do Lajeado (APA Lajeado); c) Study area d) Gradient line of pitfall traps: 1) campo sujo; 2) cerrado sensu stricto; 3) mata de galeria; 4) tabocal. Phytophysiognomies: (e) *campo sujo*; (f) *cerrado sensu stricto*; (g) *tabocal*; (h) *mata de galeria*.

Field work was conducted from September 2013 to October 2014 with the exception of July (due to unexpected logistical problems). The sampling of anurans and lizards began around the middle of each month when the buckets were opened and checked daily for seven days and then closed again on the last day. Most of the captured individuals were released after being handled, in a close by location. However, some anurans and lizards were collected and fixed, in agreements with scientific and ethical principles, being euthanized with anesthetic solution (tiopental ®). The voucher specimens were fixed using a formalin solution (10%), preserved in alcohol at 70%, and then deposited at "Coleção Herpetológica da Universidade de Brasília" (CHUNB). Handling and euthanasia were carried out in accordance with national laws and national and international guidelines on animal well-being, authorized through Fauna License provide by ICMBio, Brazil (Authorization for activities with scientific purposes n°40970) (Appendix IV).

2.3.3. Data analysis

To evaluate the efficiency of sampling effort and estimate species richness, we constructed individual-based species accumulation curves for anurans and lizards, that were smoothed using 1,000 replicates with randomization of the order of individuals. Maximum expected species richness was estimated using the Chao estimator. Species accumulation curves and richness estimates were generated using the command *specpool*, from vegan package (Colwell, 1997), R version 3.5.1 (R Core

Team 2018). We also pooled the abundances and richness of anurans and lizards for the dry and rainy season in separate, and plotted it against the phytophysiognomic gradient.

Due to the different quantities of traps per phytophysiognomies, we also use the Sander´s Method of Rarefaction (Hayek and Buzas, 1997) to generate the species richness and comparing the richness between phytophysiognomies. We estimated values of rarefied specific richness for lizards (for each vegetation) and for amphibians (for each vegetation) based on the least sampled habitat.

We used information available in the literature and on-line databases to characterize the anurans and lizards species found in this study to subsidize the discussions on the assemblages.

2.4. Results

We recorded a total of 1345 specimens from which, 30% (n= 408) were anurans and 70% were lizards (n=937). Anurans had greater number of individuals recorded during the rainy season with 364 individuals and 44 individuals during the dry season. Lizards, on the other hand, showed greater number of individuals recorded during the rainy season (n=513) but sampling was more balanced when comparing to the dry season (n=425) (Figure II). No anurans were sampled during August (peak of dry season) and the lowest records of lizards was in December, during the rainy season (n=8).

Throughout the entire study, we recorded two endemic species, two arboreal, four semi-arboreal and five semi-fossorial species. However, most of the species recorded are associated with open areas of Cerrado, namely ground-dwelling species.

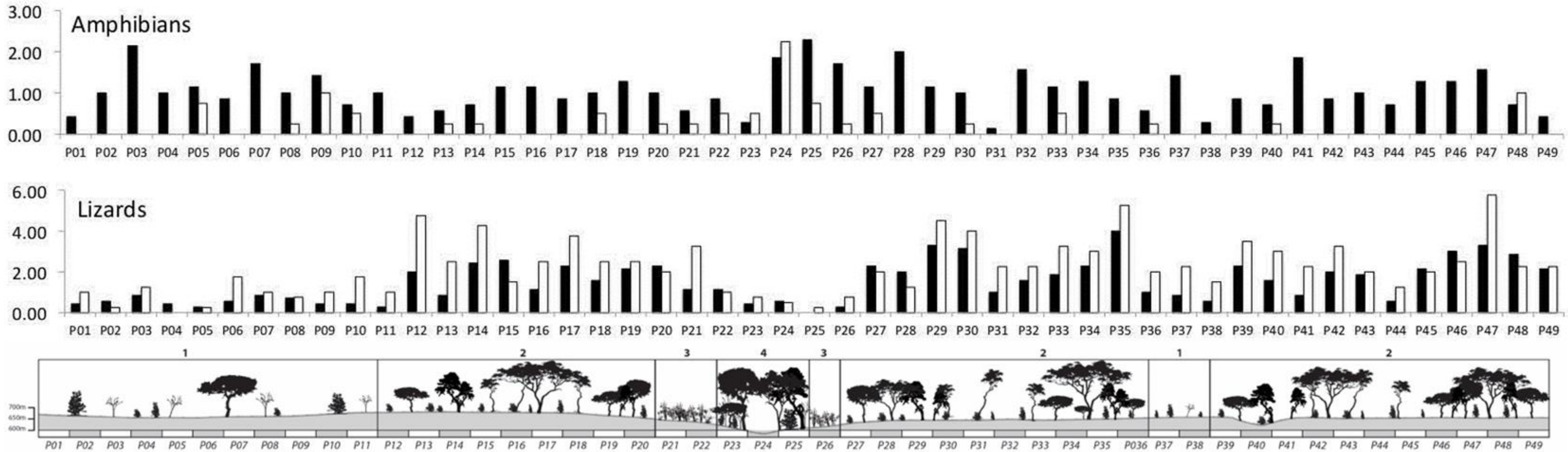


Figure II. a) Relative abundance of amphibians/anurans and lizards per sampling station (proportionally to sampling effort) in the gradient of Cerrado divided by rainy (black) and dry season (white). 1) campo sujo; 2) cerrado sensu stricto; 3) tabocal. 4) mata de galeria.

We conducted a sampling effort of 49 stations x 4 traps/buckets x 7 days during 11 months. The accumulation curves based on sampled individuals approach an asymptote at when all individuals are included in the curve (Figure III). Therefore, is no surprise that the richness estimates (Chao estimator) of 15.25 and 14.05 species of anurans and lizards are in accordance with the numbers of species actually captured during the study.

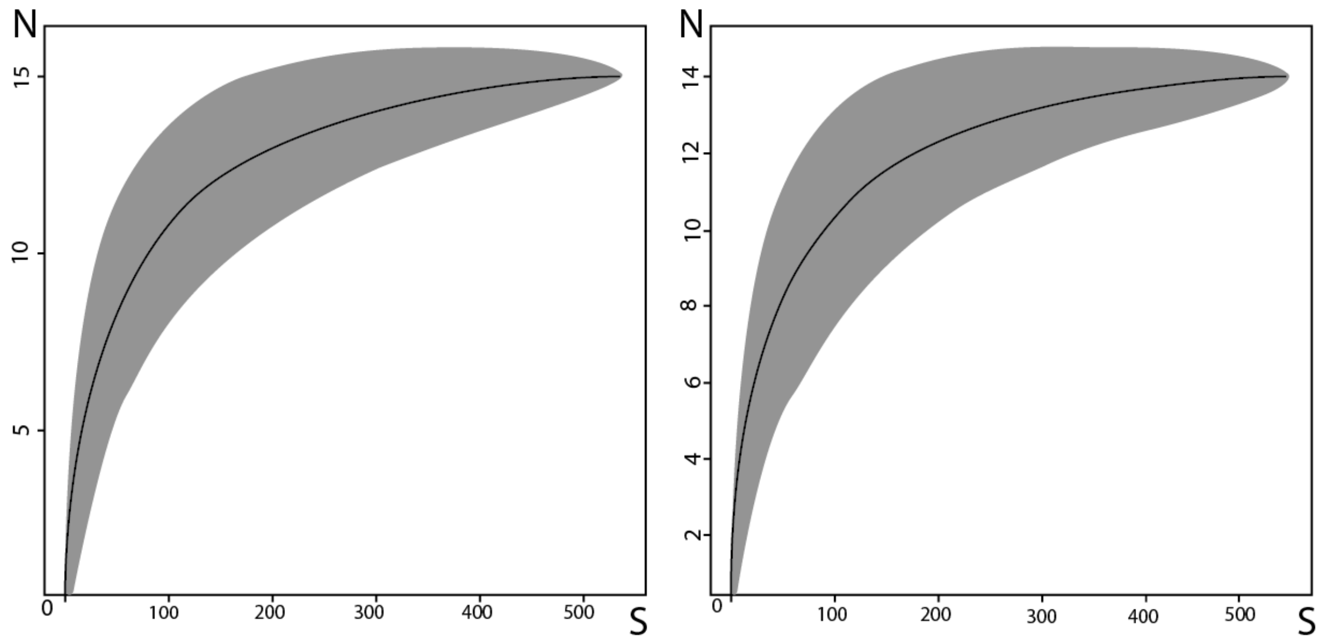


Figure III. Individual-based accumulation curves, smoothed by replication with randomization of the order of (a) anuran and (b) lizards collected at Fazenda Ecológica, Instituto Ecotropical, Palmas municipality, Tocantins, Brazil, based on the number of abundance throughout the 11 months of field excursions (between September 2013 and August 2014). N) number of species; S) number of individuals.

2.4.1. Anurans

We registered a total of 15 species composed by seven families in ten genera of anurans: BUFONIDAE (two species); ODONTOPHRYNIDAE (one species), LEPTODACTYLIDAE (seven species), CRAUGASTORIDAE (one species), HYLIDAE (one species), AROMOBATIDAE (one species) and MYCROHYLIDAE (two species) (Table I). The families LEPTODACTYLIDAE (n=230) and ODONTOPHRYNIDAE (n=126) reached the highest absolute abundances rates and the families AROMOBATIDAE (n=3) and MYCROHYLIDAE (n=4) reached the lowest absolute abundance. We recorded a highest number of individuals in *cerrado sensu stricto* with 239 records from 11 species (30 sample stations), followed by *campo sujo* with the highest species richness (n=109; 13 species; 13 sample stations), *tabocal* (n=34; seven species; three sample stations) and *mata de galeria* (n=26; five species; three sample stations).

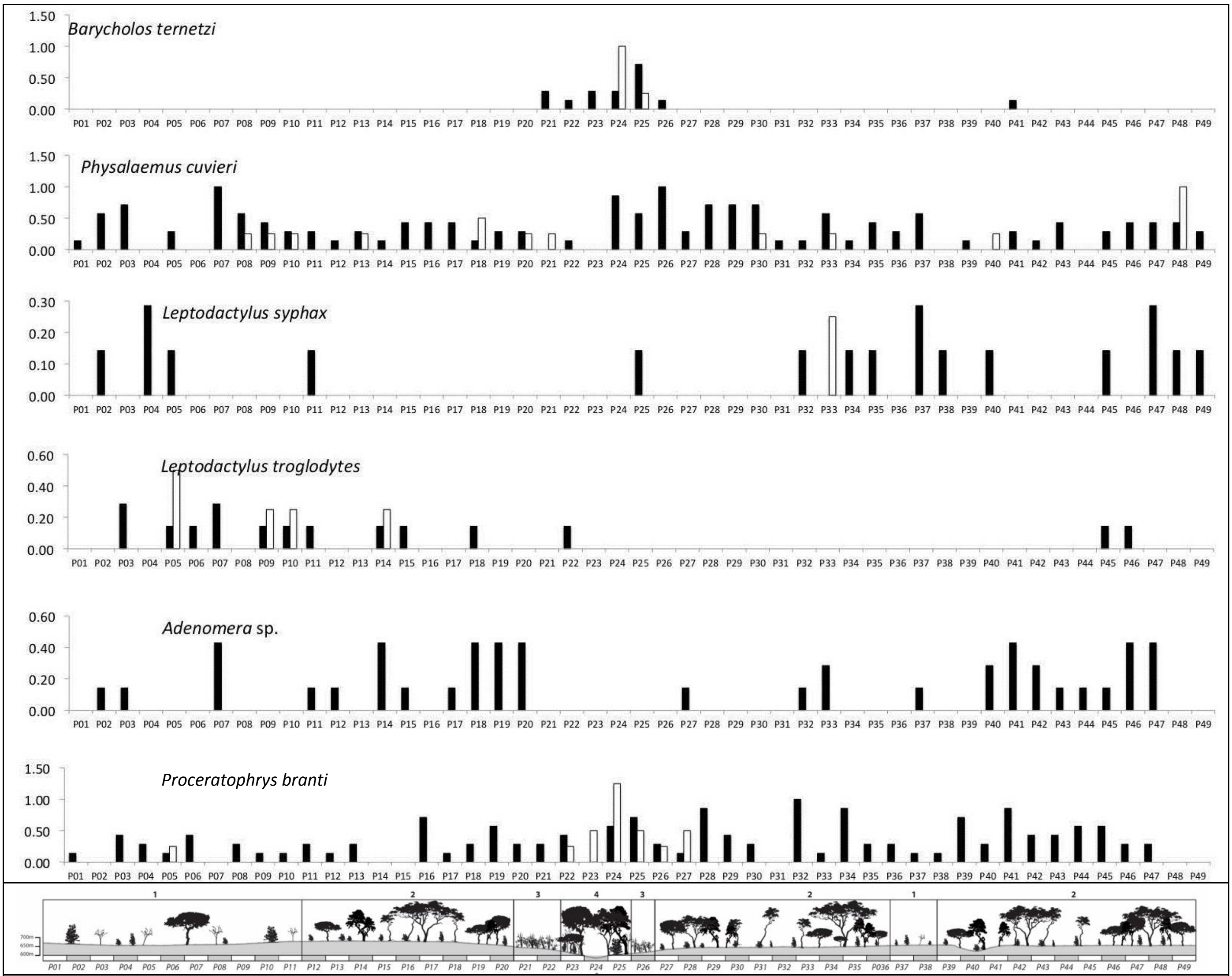


Figure IV. Relative abundance (proportionally to sampling effort) per sampling station of most abundant anurans recorded in the transect line during the rainy (black) and dry (white) season recorded in Fazenda Ecológica, Taquaruçu, Palmas, Tocantins, Brazil. 1) campo sujo; 2) cerrado sensu stricto; 3) mata de galeria; 4) tabocal.

The rarefied species richness for anurans per phytophysiognomies (table I) showed a higher species richness in *campo sujo* (nine species), followed by *cerrado sensu stricto* (seven species), *tabocal* (seven species) and *mata de galeria* (five species).

Table I. Rarefied species richness for anurans based on the least sampled habitat. N: total number of anurans; S: species richness; S^{rar}: rarefied anurans species richness.

Phytophysiognomies	**Nº stations**	**N anurans**	**S anurans**	**S^{rar} anurans (N=26)**
Campo sujo	13	109	12	9
Cerrado sensu stricto	30	228	10	7
Tabocal	3	26	7	7
Mata de galeria	3	45	6	5

***Physalaemus cuvieri* Fitzinger, 1826:** It is a species widely distributed in the east-central region of South America from north-eastern of Brazil including parts of Paraguay and Argentina (Mijares et al. 2010).

This species was the most recorded anuran with a total of 134 records with greater number of individuals recorded during the rainy season (n=119; seven months of sampling) but also with records during the dry (n=15; four months of sampling). This species showed a high amplitude of habitat being sampled in all phytophysiognomies with 82 records in the *cerrado sensu stricto*, 33 in *campo sujo*, ten in *mata de galeria* and nice *tabocal*.

***Physalaemus centralis* Bokermann, 1962:** This species is widely distributed in Cerrado areas of South America extending to south-eastern and central Brazil to north-eastern Paraguay (Bokermann, 1965).

We recorded few individuals of *P. centralis* (n=4), all sampled during the rainy season in *cerrado sensu stricto* (n=3) and *tabocal* (n=1).

***Adenomera* sp.:** This genus is distributed at the eastern regions of South America and 15 species are known to occur in Brazil (Segalla et al., 2016). We did not assigned the individuals to a species due the difficulties of species identification within this genus.

This species was only registered during the rainy season with a total of 42 anurans sampled with 36 records in *cerrado sensu stricto* and six in *campo sujo*.

***Leptodactylus syphax* Bokermann, 1969:** It is a species widely distributed in open areas of Cerrado and Caatinga biomes, often associated with rock outcrops (Heyer 1979; Frost 2007; Giaretta et al. 2008).

We registered 18 individuals during the rainy season in *campo sujo* (n=8), *cerrado sensu stricto* (n=10) and *mata de galeria* (n=1). We recorded only one *L. syphax* during the dry season in *cerrado sensu stricto* (pitfall station 33).

***Leptodactylus troglodytes* A. Lutz, 1926:** It is a species that occurs in dry and moist savanna and agricultural land, distributed throughout north-eastern, south eastern and central of Brazil, being restricted to Cerrado and Caatinga biomes (IUCN et al., 2008).

We recorded 20 specimens of *L. troglodytes*, with 15 individuals recorded during the rainy season and five during the dry season. This species was 13 recorded in *campo sujo*, six in *cerrado sensu stricto* and one in *tabocal* vegetation.

***Leptodactylus labyrinthicus* (Spix, 1824):** This is a species that can be found on open habitats and savannah enclaves in dry and moist tropical forest. It is a very adaptable species and good colonizer of anthropogenic habitat (Heyer, 2004).

We recorded eight specimens registered only during the rainy season: three in *campo cerrado*, four in *cerrado sensu stricto* and one in *tabocal* vegetation.

***Leptodactylus fuscus* (Schneider, 1799):** This frog is widely distributed and adapted to a broad range of habitats found in open country, savannas, grasslands, marshy areas, degraded forests and urban habitats (Reynolds et al., 2004).

We recorded only tree specimens during the rainy season in the open vegetation of *campo sujo.*

***Proceratophrys branti* Brandão, Caramaschi, Vaz-Silva & Campos, 2013:** It is a new species described from specimens collected in the states of Tocantins, Goiás and Minas Gerais, Brazil (Brandão et al., 2013).

This species had the second greater absolute abundance with 126 records, from which 112 were recorded during the rainy season and 14 during the dry season. During the rainy season *P. branti*s was recorded in all phytophysiognomies but during the dry season were recorded mostly in *mata de galeria* or on the edge of the forest (Figure IV). Most of the records were in the *cerrado sensu stricto* (n=81) followed by *campo sujo* (n=19), *mata de galeria* (n=17) and *tabocal* (n=9).

***Rhinella schneideri* (Werner, 1894):** This large toad is a generalist and opportunistic feeder (Caramaschi, 1981) widely distributed in South America (Pramuk, 2006).

This species was recorded only a few times (n=8), only during the rainy season, sampled in *cerrado sensu stricto* (n=5), *campo sujo* (n=2) and *tabocal* vegetation (n=1).

***Rhinella granulosa* (Spix, 1824):** This species is distributed in north-eastern Brazil (Frost, 2008; Narvaes and Rodrigues, 2009), Caatinga, Cerrado and open formations of Atlantic Rain Forest (Cardoso and Arzabe, 1993).

We recorded 15 individuals with 12 records during the rainy and three during the dry season. This species was most often captured in open grassland areas with 11 records in *campo sujo* and four in cerrado *sensu stricto.*

Barycholos ternetzi (Miranda Ribeiro, 1937): This is an endemic species to the Cerrado of Central Brazil (Pavan, 2004) commonly found in gallery forest (Bastos et al., 2003).

We recorded 19 specimens, from which 14 were captured during the rainy season and five during the dry season. Seven records in *cerrado sensu stricto*, eight in *mata de galeria* and four in *tabocal* vegetation.

***Bokermannohyla pseudopseudis* (Miranda-Ribeiro, 1937):** This is an endemic specie to Brazil. It is typically found in open fields or savannas on rocky areas of highlands, mainly in the Cerrado biome.

This species was recorded four times during the rainy season, in *cerrado* (n=3) and *campo sujo* (n=1).

***Allobates crombiei* (Morales, 2002 "2000"):** This species is known to the Amazon region but recently recorded in Cerrado biome (Carrilho et al, 2017).

We recorded this species only twice, one in *campo sujo* and one in *mata de galeria,* all during the rainy season.

***Chiasmocleis albopunctata* (Boettger, 1885):** This species is distributed from the Eastern of the Department of Santa Cruz in Bolivia, through Paraguay, to the Central and Southeastern Brazil. *C. albopunctata* lives in open areas in savannahs and dry forests of Bolivia (Aquino *et al.;* 2004).

This species was recorded once in *campo sujo* during the rainy season.

Elachistocleis cesarii (Miranda Ribeiro (1920): This species is found in open areas of Cerrado, Pantanal, Atlantic forest and Caatinga domain (Caramaschi, 2010).

We registered three specimens of *E. cesarii* recorded during the rainy season at the open area of *campo sujo*.

Table II. Anuran families, species, abundance total, abundance rainy season and dry season, abundance per phytophysiognomies. Microhabitat (Mic): T – terrestrial, A: arboreal, Sa: semi-arboreal, Sf: semifossorial; Habitat (hab): O - open area, F = forest; Diel: D = diurnal, N = nocturnal; Distribution (Dis): Ce – Cerrado, Ca - Caatinga; Ch – Chaco, Am – Amazônia, Ma - Mata Atlântica, W – widespread E: endemic; ST: number of pitfall stations. SP: sample period.

Taxon	Total (n=408)	dry season 4SP	rainy season 7SP	Phytophysiognomies				Ecology			
				Cs 13 ST	C 30 ST	Mg 3 ST	Tc 3 ST	Mic	Hab	Diel	Dis
LEPTODACTYLIDAE											
Physalaemus cuvieri	134	15	119	33	82	10	9	T	O	N	W
Physalaemus centralis	4	0	4		3		1	T	O	N	Ce Ch
Adenomera sp.	42	0	42	6	36			T	O	N	-

Leptodactylus syphax	19	0	19	5	13	1		T	O	N	Ce Ca
Leptodactylus troglodytes	20	5	15	13	6		1	T	O	N	Ce Ca
Leptodactylus labyrinthicus	8	0	8	4	3		1	T	O	N	W
Leptodactylus fuscus	3	0	3	3				T	O	D N	W
ODONTOPHRYNIDAE											
Proceratophrys branti	126	14	112	19	81	17	9	T	O/F	D N	Ce
BUFONIDAE											
Rhinella schneieri	8	0	8	2	5		1	T	O	N	W
Rhinella granulosa	15	3	12	11	4			T	O	N	Ce Ca Ma
CRAUGASTORIDAE											
Barycholos ternetzi	19	5	14		7	8	4	T	F	N	E
HYLIDAE											
Bokermannohyla pseudopseudis	4	0	4	1	3			A	O	N	Ce
AROMOBATIDAE											
Allobates crombiei	2	0	2	1		1		T	O/F	N	Ce Am
MYCROHYLIDAE											
Chiasmocleis albopunctata	1	0	1	1				Sf	O	N	W
Elachistocleis cesarii	3	0	3	3				Sf	O	N	W

2.4.2. Lizards

We recorded 937 lizards distributed by 14 species from 12 genera and seven families: TROPIDURIDAE (one species), TEIIDAE (four species), POLYCHROTIDAE (one species), DACTYLOIDAE (two species), PHYLLODACTYLIDAE (one species), GYMNOPHTHALMIDAE (three species), and MABUYIDAE (two species) (Table II). The families with the most abundance of records were TROPIDURIDADE (n=536), TEIDAE (n=259) and GYMNOPHTHALMIDADAE (n=98). The lowest number of records are represented by the families PHYLLODACTYLIDAE (one species), DACTYLOIDAE (two species) and POLYCHROTIDAE (one species). We registered 782 lizards in the *Cerrado sensu* stricto (30 sampling station), 107 in *campo sujo* (13 sampling stations), 38 in *tabocal* (three sampling stations) and 11 *mata de galeria* (three sampling stations).

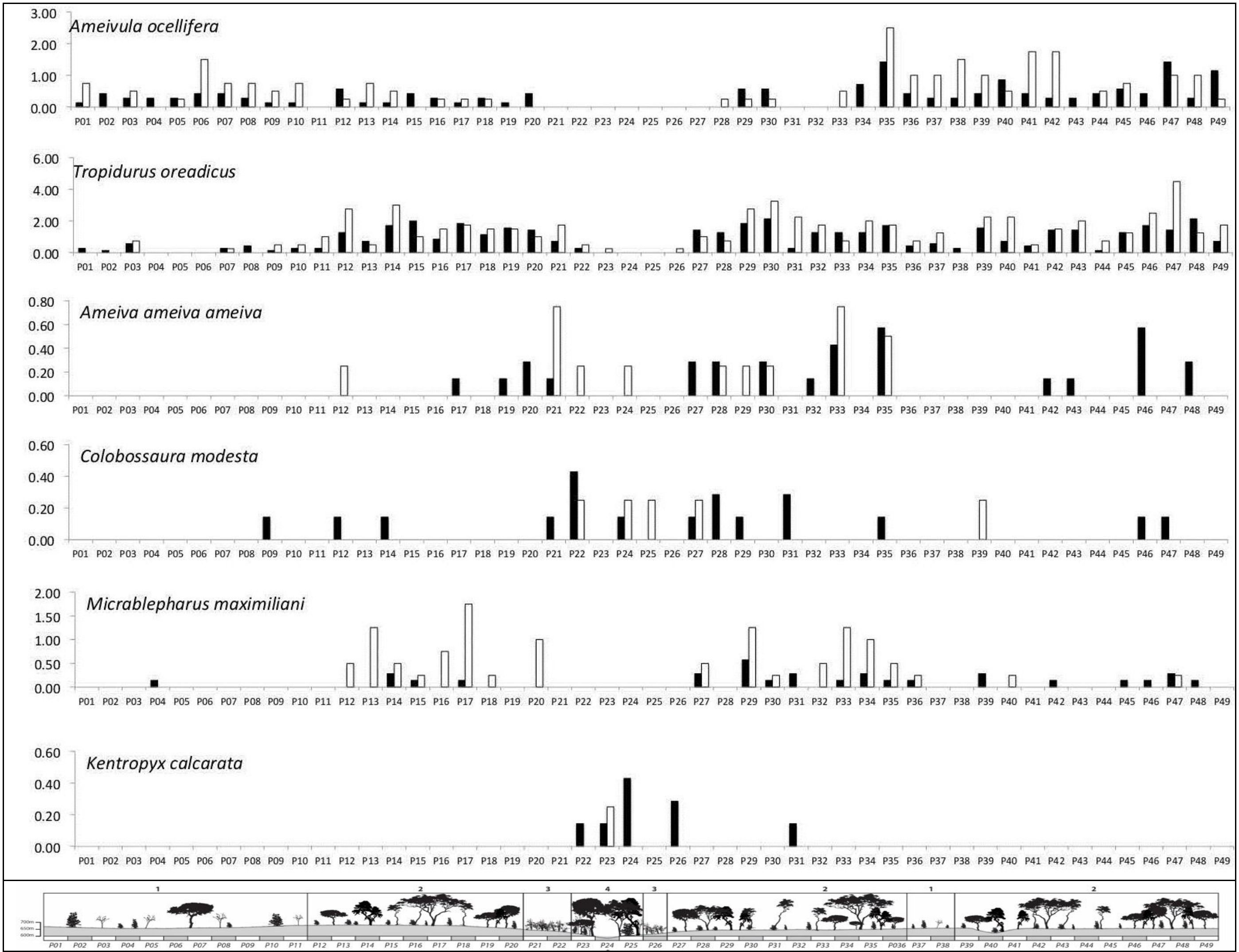


Figure V: Relative abundance (proportionally to sampling effort) per sampling station of most abundant lizards recorded in the transect line during the rainy (black) and dry (white) season recorded in Fazenda Ecológica, Taquaruçu, Palmas, Tocantins, Brazil. 1) campo sujo; 2) cerrado sensu stricto; 3) mata de galeria; 4) tabocal.

The rarefied species richness for lizard per phytophysiognomies (table III) showed a higher species richness in *tabocal* (six species), followed by *cerrado sensu stricto* (four species), *mata de galeria* (five species) and *campo sujo* (three species).

Table III. Rarefied species richness for lizards based on the least sampled habitat. N: total number of lizards; S: species richness; S^{rar}: rarefied lizard species richness.

Phytophysiognomies	**Nº stations**	**S lizards**	**S^{rar} lizards (n=13)**
Campo Sujo	13	7	3
Cerrado sensu strictu	30	14	4
Tabocal	3	9	6
Mata de Galeria	3	5	5

***Tropidurus oreadicus* Rodrigues, 1987:** This is a species commonly found in open vegetation habitats (Colli et al., 1992) with distribution to the Central Brazilian

Cerrado areas and occurring also in open enclaves in the Amazonian forest (Rodrigues, 1987).

T. oreadicus was the most recorded species with 536 individuals sampled, 300 during the rainy season (seven months) and 236 during the dry season (four months). We recorded 478 individuals in c*errado sensu stricto*, followed by 40 in *campo sujo* (n=40) and 17 in tabocal (n=17). A single specimen was recorded inside de *mata de galeria* during the dry season.

Ameivula ocellifera (Spix, 1825): This species is widely distributed to Brazil with occurrence in the Cerrado biome (Vitt, 1991; Mesquita and Colli, 2003), Caatinga biome and found in sandbanks in the northeast Brazilian coast (Dias and Rocha, 2004).

We recorded 209 individuals, 95 during the dry season and 114 during the rainy season. This species was recorded in c*ampo sujo* (n=57) and in *cerrado sensu stricto* (n=152) and not recorded close to the *mata de galeria* or *tabocal.*

Ameiva ameiva ameiva (Linnaeus, 1758): This species is widely distributed in the Neotropics (Peters and Donoso-Barros, 1986), low elevation habitat type and altered habitat as cities (Vitt and Colli, 1994).

We had a total of 41 records with 14 individuals registered during the dry season and 27 during the rainy season. This species was recorded in *cerrado sensu stricto* (n=35), *tabocal* (n=1) and *mata de galeria* (n=5), but not recorded in *campo sujo.*

Kentropyx calcarata Spix, 1825: This is a forest species with a distribution from north of Cerrado to Amazon (Avila-Pires, 1995; Borges-Nojosa & Caramaschi, 2003; Nogueira *et al.*, 2009b).

We recorded nine specimens, eight during the rainy season and one in the dry season. *K. calcarata* was more recorded in *mata de galeria* with five records, followed by 3 records in *tabocal* and one in the *cerrado sensu stricto* vegetation.

Polychrus acutirostris Spix, 1825: This species inhabits open formations of South America to east of the Andes (Ávila-Pires, 1995).

This species was little recorded with a total of nine records during the dry season. Six individuals recorded *cerrado sensu stricto*, two in *campo sujo* and one in *tabocal* vegetation.

***Norops brasiliensis* (Vanzolini & Williams, 1970):** This is a species with distribution to open formation of Amazon region (Ávila-Pires, 1995) and Cerrado (Mesquita et al., 2008) with a population recorded in Chapada do Araripe (Willians and Vanzolini, 1980).

This species was recorded once during the rainy season in *cerrado sensu stricto*.

Norops meridionalis (Boettger, 1885): This species inhabits open grassy habitats (Nogueira et al., 2009), gallery forests (Langstroth, 2006), rocky outcrops (Uetanabaro et al., 2007), seasonally flooded open areas and perianthropic areas (Vaz-Silva et al., 2007).

We recorded nine specimens with five records in *cerrado sensu stricto* and four in *tabocal* vegetation. Five individuals were registered during the rainy season and four during the dry season.

Gymnodactylus geckoides Spix, 1825: This is a species usually found in open fields and open vegetation associated with shelters (Colli et al., 2003b; Vitt et al., 2007).

We sample ten specimens with six records in *cerrado sensu stricto* and four in *campo cerrado*. This species were more recorded during the dry season (n=7) than the rainy season (n=3).

Micrablepharus maximiliani (Reinhardt & Luetken, 1862): It is a species distributed in Cerrado, Pantanal e Caatinga biomes (Freire 1996, Colli et al., 2002).

This species was recorded 76 times for all study, with 75 individuals registered in *cerrado sensu stricto* and one in *campo sujo*. We recorded 49 during the dry season and 27 during the rainy season.

***Colobosaura modesta* (Reinhardt & Luetken, 1862):** This species is commonly found in Cerrado biome (Colli et al., 2002) and also in forest on Caatinga (Borges-Nojosa and Caramaschi, 2003).

We recorded 22 specimens with 17 individuals recorded during the rainy season and five during the dry season. We registered more individuals in *cerrado sensu stricto* (n=14), followed by *tabocal* (n=5) *mata de galeria* (n=2) and *campo sujo* (n=1).

Copeoglossum nigropunctatum (Spix, 1825): *C. nigropunctatum* is widely distributed in South America occurring in forest regions in the Amazon, Atlantic Forest and gallery forests in the Cerrado areas and forest edges.

Only four *C. nigropunctatum* were recorded, three during the rainy season and one in the dry season. We recorded this species in *cerrado sensu stricto* (n=3) and *tabocal* vegetation (n=1).

Notomabuya frenata **(COPE, 1862):** This species is widely distributed within of Brazil typically associated to the Chaco and Cerrado biomes (Colli et al., 2002).

Six specimens were registered, five during the rainy season and one during the dry season. This species were records in all vegetation: one in the *campo sujo*, two in *campo cerrado*, two in *mata de galeria* and one in the *tabocal.*

Cercosaura ocellata petersi Ruibal, 1952: This species was recently recognized as a new species that occurs in the Cerrado, Atlantic forest, Pantanal and Pampas (Sturaro et al., 2015).

We recorded a total of three individual, with two in *cerrado sensu stricto* and one *tabocal* vegetation. Two during the dry season and one at the rainy season.

Tupinambis quadrilineatus Manzani & Abe, 1997: This species is endemic from the Brazilian Cerrado (Colli et al., 1998) primarily associated with forested habitats of Cerrado. (Colli et al., 1998).

We sampled two *T. quadrilineatus,* both records in *cerrado sensu stricto* with one record during the rainy season and one during the dry season.

Table IV. Lizard families, species, abundance total, abundance rainy season and dry season, abundance per phytophysiognomies. Microhabitat (Mic): T – terrestrial, A: arboreal, Sa: semi-arboreal, Sf: semifossorial; Habitat (hab): O - open area, F = forest; Diel: D = diurnal, N = nocturnal; Distribution (Dis): Ce – Cerrado, Ca - Caatinga; Ch – Chaco, Am – Amazônia, Ma - Mata Atlântica, W – widespread E: endemic; ST: number of pitfall stations. SP: sample period.

Taxon	**Total** (n=937)	**dry season** (4SP)	**rainy season** (SP7)	**Phytophysiognomies**				**Ecology**			
				Cs 13 ST	**C** 30 ST	**Mg** 3 ST	**Tc** 3 ST	**Mic**	**Hab**	**Diel**	**Dis**
TROPIDURIDAE											
Tropidurus oreadicus	536	236	300	40	478	1	17	T	O	D	Ce
TEIIDAE											
Ameivula ocellifera	209	95	114	57	152			T	O	D	W
Ameiva ameiva ameiva	41	14	27		35	1	5	T	O	D	W
Kentropyx calcarata	9	1	8		1	5	3	T	F	D	Ce Am
Tupinambis quadrilineatus	2	1	1		2			T	O	D	E
POLYCHROTIDAE											
Polychrus acutirostris	9	9		2	6		1	A	O	D	W
DACTYLOIDAE											

Norops brasiliensis	1		1		1			Sa	O	D	Ce
Norops meridionalis	9	4	5		5		4	Sa	O	D	Ce
PHYLLODACTYLIDAE											
Gymnodactylus geckoides	10	7	3	4	6			T	O	N	Ce
GYMNOPHTHALMIDAE											
Micrablepharus maximiliani	76	49	27	1	75			Sf	O	D	Ce
Colobosaura modesta	22	5	17	1	14	2	5	Sf	F	D	Ce Ca Ch
Cercosaura ocellata petersi	3	2	1		2		1	Sf	O	D	Ce
MABUYIDAE											
Copeoglossum nigropunctatum	4	1	3		3		1	Sa	F	D	Ce
Notomabuya frenata	6	1	5	1	2	2	1	Sa	F	D	Ca Ce

2.5. Discussion

The objective of this study was to inventory the anurans and lizard assemblages, to know their local distribution and richness in a natural area formed by different types of vegetation (phytophysiognomies) in the north region of Cerrado biodiversity hotspot, through the use of pitfall traps distributed in a line crossing the vegetation. Besides uncovering the composition of anuran and lizard assemblages in this area, it was possible to understand the species distribution throughout the seasonal changes in the phytophysionomical gradient. Therefore, information such as local richness, richness per phytophysiognomy, local distribution, endemism and changes in the local distribution inside de gradient were identified in this inventory.

2.5.1. Assemblages in the phytophysionomical gradient

We registered a high species richness is this study with most records of ground-dwelling species. Nevertheless, six arboreal/semi-arboreal species (*B. cf. pseudospseudis, P. acutirostris, N. meridionalis, N. brasiliensis, C. nigropunctatum, N. frenata)* were recorded. In general, the anuran and lizard assemblages were composed by species associated to Cerrado biome, Caatinga, Amazonia, widespread species as well as endemic species from Brazil and Cerrado. The herpetofauna community sampled in this study is relatively influenced by Caatinga biome with many species shared with this biome. The composition of species is similar with studies carried out in north and northeast of the Cerrado (Nogueira et all., 2009; Nogueira et al., 2011; Pavan and Dixon, 2004; Valdugo, 2011; Recoder et al., 2011; Santos et al., 2014) and the different species recorded in our study are related to the new taxonomic names proposed in the last years. For example, the species *P. brant* (before *P. goyana,* divide in three new species), *Cercosaura ocelata* were recently reclassified as a new species in the last years.

The highest rarefied species richness of anurans were found in *campo sujo* (nine species), followed by *cerrado sensu stricto* (seven species)*, tabocal* (seven species) and *mata de galeria* (five species). The highest species richness of lizards were recorded in *tabocal* (six species), followed by *mata de galeria* (five species)*, cerrado sensu stricto* (four species) and *campo sujo* (three species). Although the Cerrado has a significantly higher richness of open areas species (Nogueira, et al., 2009) as we observed with the anurans richness, the lizards seems to present the highest species richness in the phytophysiognomies that are in contact with other vegetation. The turnover of species between regions can increase species richness (Connel, 1978) observed in anurans but more intensely with the lizard communities. Species that are not typically from a specific phytophysiognomy can be recorded in other phytophysiognomies increasing the species richness. The presence of open area on the border of the forest can result in the occurrence of typical species of open areas and forest (Pombal Jr. 1997).

The *tabocal* vegetation was located between the *cerrado sensu stricto* and *mata de galeria* and could not be recognized as a Cerrado phytophysiognomy, but was formed by super population of *Guadua* sp. creating a new habitat. Nevertheless, we had a high specie richness of anurans and lizards in this vegetation.

With regard to the local distribution of anuran and lizard assemblages within the physiognomies, we recorded: (1) species that occupied both open areas of Cerrado such as *campo sujo* and *cerrado sensu stricto*, (2) species restricted to savanna area as *cerrado sensu stricto*, (3) species recorded in the forest with records on the edge of the forest (4) and species recorded in all gradient. This varied distribution in the gradient give support to the view that the herpetofauna in Cerrado biome is formed by complex, rich and characteristic communities strongly associated to specific microhabitats (Gainsbury and Colli, 2003; Mesquita et al. 2006a, Bastos, 2007, Brandão and Araújo 2001) unevenly distributed in a heterogeneous habitat (Colli et al, 2002, Nogueira et al. 2005, Nogueira, 2009).

2.5.2. Assemblages within the seasonal gradient

The vast majority of anurans (89% of the abundance, 364 individuals from15 species) were registered during the rainy season (seven months of sampling) but five species continued been recorded during the dry season (four months of sampling) such as *P. cuvieri, L. troglodytes, P. branti, R. granulosa* and *B. ternetzi.* Despite being active in the dry season, these species were not necessarily breeding. The Cerrado has a well-defined seasonality where the majority of anurans species present reproductive activity during the rainy season, with abundancies influenced by rain and temperatures (Bastos, 2007). Therefore, we had a low level of records during the dry months (September, May, June and August) and we didn't record anurans during the driest month (August), reflecting the ecological needs of anurans related to the rainy season.

Likewise, lizards were more recorded during the rainy season with balanced records between both seasons in which 55% of lizards (n=513) were recorded during the rainy season (seven month of sampling) and 45% (n=425) were recorded during the dry season (four months of sampling). Lizard assemblage were more distributed within the phytophysiognomies during both seasons, being less effected by the seasonal changes. Lizards must meet their thermoregulatory needs to perform their activities with strict relation with the temperature (Novaes-e-Silva and Araújo 2008). Thus, we recorded the lowest abundance of lizards during the lowest temperature and highest precipitation (December). Only one species was recorded exclusively in the rainy season (*Norops brasiliensis*), and only one species with records exclusively during the dry season (*Polychrus acutirostris*).

2.5.3. Relation between phytophysiognomies and seasonality

Despite the faunal overlap between open and forested areas is limited (Nogueira, et al,. 2009), anuran and lizard species can apparently benefit itself by: expanding or retracting their habitat breadth, being relatively flexible in its local distribution along the phytophysionomical gradient, probably in order to cope with the steep seasonal variation. This trend was observed with almost all species, both in the case of open areas and forest species (Figure V and IV). An example of this tendency related to the behaviour mentioned above is with the species *P. branti* that was recorded in all phytophysiognomies during the rainy season but not during the dry season. In fact, during the drier months, this species was recorded only in the forested area or at its borders. In this case is possible that *P. branti* increased its abundance in *mata de galeria* due the reproductive period (Brandão and Araújo, 2001). Another species recorded in all phytophysiognomies is the lizard *T. oreadicus,* which was very abundant. This species was however recorded more often near or inside the forested physiognomies during the dry season (Figure V). The inverse was observed with the forest species *B. ternetzi* and *K. calcarata*: during the dry season these species remained mostly inside the *mata de galeria* but during the rainy season these forest species could amplify your habitat range being recorded extra *mata de galeria,* as *tabocal* and *cerrado sensu stricto* (Figure IV and V).

In general, the seasonal changes can induce changes in the distribution of species in the phytophysionomical gradient. In this study we observe general patterns of anuran and lizard assemblages for the hypothesis that "the seasonal changes in the Cerrado promote changes in the local distribution of anurans and lizards into the gradient of Cerrado vegetation". The heterogeneity of the Cerrado provide discontinuous and different habitats that promote the species turnover among phytophysiognomies (beta-diversity). High turnover in South American lizard assemblages is known in forest habitat (Colli et al., 2002), but not reported to anurans due their ecological needs (Haddad and Sawaya, 2000; Toledo et al., 2003Giaretta et al., 2008). However, we could observe the same trend with the anuran assemblages: a turnover of species among phytophysiognomies.

Here we observe the general local distribution and richness patterns for anurans and lizards in a vegetation gradient of Cerrado, however it is important to isolate the influence of particular environmental variables, in order to better understand which factors influence the variation on the distribution of anuran and lizards species along the gradient of Cerrado vegetation.

2.5.4. Implications for conservation of Cerrado biodiversity hotspot

Besides the forest environments, open areas are also important for the maintenance of species richness (Nogueira et al., 2009), and the diversity of phytophysiognomies ensures that the niches of each species are kept in its area (Campos et al., 2013). Thus, the mosaic of Cerrado plays an important role in maintain the diversity of species, by ensuring the diverse ecological needs of the assemblages (Brandão & Araújo 2001, Colli et al. 2002, Nogueira et al. 2009). In addition, it is possible that seasonal changes may influence local distribution within the phytophysiognomies, followed by the great seasonal variation in order to refuge (Knutson et al. 1999), feed, aestivation and migration (Stebbins & Cohen 1995, Gibbs 1998, Marsh & Trenham 2001; Weyrauch & Gubb Jr. 2004). It´s possible that different phytophysiognomies do not work as a barrier, but as new habitats that provide new opportunities and resources to be explored as a consequence of seasonal changes. Thus, it is extremely important to keep the heterogeneity of the Cerrado biome, protecting the mosaic of vegetation in order to maintain the diversity of species and the ecosystem services it provides.

There is the lack of basic studies with herpetofauna in Cerrado - many areas are not yet sampled in the Cerrado biome - and studies relating seasonal changes with the local distribution within the phytophysionomical gradient are still scarce. Thus, besides the study area is important for the conservation – because is an environmental protection area, tourist region and is a region of the Cerrado with eminence of potential of anthropogenic impacts - this study is also trying to contribute about the importance of the mosaic of vegetation in the Cerrado biome, seeking to understand the changes on the local distribution along the gradient promoted by the great seasonal changes. This inventory model of fauna sampling using a gradient-line, allowed to register a high number of species in a small area, but also understand the species dynamics throughout the time within the various physiognomies. Anurans and lizards are ectotherms, and habitat alteration and climate changes affect strongly these communities (Klink e Machado, 2005; Machado et al., 2004). Thus, this work evidences the importance of understanding the dynamics of species assemblages in a Cerrado mosaic. In the end, this study increases the knowledge of the Brazilian savanna herpetofauna, mainly in the northern region of the Cerrado, being useful to the elaboration of conservation actions for this biome as long as the Brazilian Cerrado continues to be affected by anthropogenic impacts.

Chapter III

3. Factors affecting the local distribution of the lizard *Tropidurus oreadicus* along a phytophysionomical gradient of the Cerrado hotspot.

3.1. Abstract

Brazil ranks third in reptile diversity in the world, with 795 species, from which 47% are endemic. *Tropidurus oreadicus* is a terrestrial, diurnal and heliophilous lizard species endemic from Brazil. This species is commonly found in open vegetation habitats, usually in high density, and is distributed in the central Brazilian Cerrado and also in natural savanna fragments in the Amazonian forest. Nowadays, the Cerrado biome is highly threatened due to innumerous environmental impacts and only 50% of its original formation still remains. In face of the current threats and impacts, is of utmost importance to understand the environmental factors that influence the distribution of this species, at the local scale, in the Cerrado biome. We sampled the species in a Cerrado phytophysionomical gradient using pitfall traps. We captured a total of 536 lizards belonging to *T. oreadicus* species in all phytophysiognomies. The local distribution of the species along the gradient was modelled using generalized linear mixed models (GLMM) and variables that could work as proxys for different factors (phytophysiognomies, meteorological, seasonal, microhabitat and climatological). Local distribution of *T. oreadicus* was best explained by season (explaining 9.7% of the variation), followed by meteorological conditions (9.2%), the climatic patterns of the last 30 years (7.8%), phytophysiognomies (5.2%) and microhabitat conditions (4%). Our results show that: (i) the variation on local distribution of lizard *T. oreadicus* occurs in response to different categories of environmental variables; (ii) all categories (phytophysiognomies, meteorological, seasonal, microhabitat and climatological) have a significant influence in the distribution of the model species. The seasonal, meteorological and climatological models acted more intensely to explain the local distribution of *T. oreadicus* within the gradient. The seasonal category seems to be the strongest model to explain the distribution of *T. oreadicus* due the highest explained deviance and lower ΔAICc. The phytophysiognomies and microhabitat models contains the local components present in the habitat and microhabitat of Cerrado´s areas, that were also a strongly influence in the distribution of this species model. Perhaps, in response to heterogeneity of cerrado habitat, the various environmental variables influence the local distribution.

Keywords: Squamata; Tropiduridae; Local distribution, Gradient of Cerrado, Ecological modelling, GLMM, Phytophysiognomies, Meteorological, Temporal, Climatological, Microhabitat, APA Serra do Lajeado.

3.2. Introduction

There are currently 10,793 species of reptiles in the world (Uetz, 2018) and Brazil has the third richest reptile fauna in the world, with 795 species (Costa and Bérnils, 2018). Reptile species endemic to Brazil represent 47% of all recorded species in the country. Brazil has 276 lizards (Squamata) but this figure continues to increase steadily, with 17 new species described between 2016 and 2018 (Costa and Bérnils, 2018).

The Cerrado biome is the second largest Neotropical domain with extension of 2 million km², corresponding to 23% of the total area of Brazil, only smaller than the Amazonian biome (MMA, 2011). The vegetation of Cerrado biome is characterized by a heterogeneous structural complexity in a horizontal distribution formed by *forest*, *savanna* and *grassland* formation with eleven phytophysiognomies (Ribeiro and Walter, 1998). Although Cerrado biological diversity has been undervalued in the past, the biome is currently recognized as the most biodiverse tropical savannah in the world (Klink and Machado, 2005). The Cerrado harbours a high diversity of lizards with numerous endemic species (Colli et al., 2002) and ranks second in terms of diversity of lizard in Brazil (Rodrigues, 2005, Nogueira et al., 2009) with 276 lizard species, from which 54% are endemics (Costa and Bérnils, 2018). Lizards have been used as model organism for ecological research (Vitt and Pianka, 1994).

The genus *Tropidurus* (Tropiduridae) includes 23 species and four groups (*spinulosus, bogerti, semitaeniatus and torquatus*), with 17 species endemic to Brazil. *Tropidurus oreadicus* belongs to *torquatus* group and is a terrestrial, diurnal and heliophilous lizard species, commonly found in open vegetation habitats (Colli et al., 1992). This species is distributed in the Central Brazilian Cerrado areas and also in open enclaves in the Amazonian forest (Rodrigues, 1987). Some studies have focused in different aspects of the ecology of *Tropidurus oreadicus* (Faria and Araújo, 2004; Rocha and Bergallo, 1990; Meira et al., 2007), but few studies have focused in the effects of the variables on the local distribution of this species. This species is locally abundant and well distributed in Cerrado, being a model organism for baseline studies (Colli, et al., 2002). Some studies with the syntopic lizard *T. torquatus* indicate that body temperatures were significantly related to the air temperature, but also to the substrate, indicating that the heat sources play an important role in the thermoregulation of the population of this species in different environments (Kiefer et al., 2005).

With this study, we aim to identify the factors that influence the local distribution of *T. oreadicus* in a phytophysionomical gradient of the Cerrado hotspot, throughout the year. We hypothesize that *Tropidurus oreadicus* local distribution patterns will be influenced by meteorological and/or climatic conditions because lizards are ectotherms and they are temperature dependent to perform their activities. If distribution patterns are mostly a result of individual responses, we expect a stronger influence from short-term (i.e. meteorological) variations. On the other hand, if distribution patterns are better explained by long-term variations (climatic patterns) then it is most likely that distribution shifts are mostly a populational response to environmental change. With this information, we expect to improve the knowledge on the ecology of Cerrado lizard species and its relation with the environment, in order to inform conservation strategies for Cerrado.

3.3. Materials and Methods

3.3.1. Study area and sampling design

This work was conducted in the Environmental Protection Area Serra do Lajeado, at Fazenda Ecológica (Ecotropical Institute) located in the municipality of Palmas, district of Taquaruçu, State of Tocantins, Brazil. The chosen region to sampling *T. oreadicus* is inserted in the Cerrado domain with different types of vegetation (forest, savanna and grassland formations) creating a vegetation gradient formed by four phytophysiognomies types: *campo sujo*, *cerrado sensu stricto, tabocal* and *mata de galeria* (see figure I, Chapter II).

As a survey method, we installed 49 station of pitfall traps arranged in line 50m from each other forming a transect line of 2,5 kilometres crossing the vegetation gradient described above. The field work was conducted from September 2013 to October 2014 with the exception of July (due to unexpected logistical problems). The sampling began around the middle of each month. The sampling period started when the buckets were opened and these were checked daily, for seven days, and closed again on the last day.

3.3.2. Environmental data collection

In order to analyse the influence of different factors on the local distribution of *T. oreadicus*, we collected data on 34 environmental variables related to five categories: *phytophysiognomies*, *meteorological, seasonal, microhabitat and climatological* (Table VI). The microhabitat variables were collected using a square of 50 x 50 cm, subdivided into 25 squares of 10 x 10 cm, with which we measure leaf litter, herbaceous, bare soil and canopy cover. The microhabitat variables were collected once during the rainy season (February) and once during the dry season (August). The *seasonal* model are related to the month (eleven months of survey) and season (dry and rainy). The *meteorological* and *climatological* variables were retrieved from INMET (National Institute of Meteorology) for all the dates included in the sampling period. The climatic patterns for the last 30 years (NC) consisted on the average of the values collected during 30 years of continuous. The phytophysiognomies were classified according to Ribeiro and Walter (1998) and we measure the distance from each station to the closest edge of each phytophysiognomy using the measurement tool in Google Earth.

Table VI. List of environmental variables included in this study, by category, with reference to units and descriptions of each variable. The variables in the table are the ones that were selected after removing highly correlated variables.

Category	Variable	Units	Description
Phytophysiognomies	Fito	Categorical	Phytophysiognomy: *campo sujo, cerrado sensu stricto, mata de galeria* and *tabocal*
	Distsujo	meters	Distance from *campo sujo*
	distcerrado	meters	Distance from *cerrado sensu stricto*
	disttabocal	meters	Distance from *tabocal*
	distmata	meters	Distance from *mata de galeria*
Meteorological	PreSa	mm	Precipitation during 7 days (average)
	TminSa	° C	Minimum temperature of 7 days (average)
	TminMo	° C	Minimum on month (average)
	TmaxSa	° C	Maximum temperature during 7 days (average)
Seasonal	month	Categorical	Month of the survey (11 months)
	Season	Categorical	Season of the survey (rainy and dry)
Microhabitat	NTD	meters	Nearest tree distance
	NTC	meters	Nearest tree circumference
	Trees	Count	Number of trees in the pitfall trap station
	stems	Count	Number of stems in the pitfall trap station
	shrubs	Count	Number of shrubs in the pitfall trap station
	termites	Count	Number of termites in the pitfall trap station
	logs	Count	Number of logs in the pitfall trap station
	burrows	Count	Number of burrows in the pitfall trap station
	rocks	Count	Number of rocks in the pitfall trap station
	leaflitter	g	Leaf litter weight in the pitfall trap station
	herbaceous	square	Number of square with herbaceous vegetation (per station)
	baresoil	square	Number of square with bare soil (per station)
	canopy	square	Number of square with canopy (per station)
Climatological	TminNC	° C	Minimum temperature of 30 years
	TmedNC	° C	Mean temperature of 30 yeah
	PreNC	mm	Precipitation of 30 years
	InsulNC	*	Insolation of 30

3.3.3. Data analysis

To analyse the effects of the environmental variables on the distribution of *T. oreadicus*, all numerical variables were standardized to minimize the effect of different measurement scales. First, we used Spearman's rank correlation coefficient to identify potential highly correlated variables. We decided to use correlation coefficient above 0.7 for descriptor that were highly correlated (Dormann et al., 2012). After this, we used the *glmer* function of the *Lme4* package (Crawley, 2012) to estimate the best models through a manual forward selection procedure (Appendix V). Models were selected based on the corrected Akaike information criterion (AICc), corrected for a small ratio of observations to environmental variables (Burnham and Anderson, 2004). All the ecological modelling was performed using the software R Studio version 3.5.1.

3.4. Results

We recorded the species *T. oreadicus* in all phytophysiognomies, with a total of 536 records and most lizards sampled in *cerrado sensu stricto* (n=478; 20 sampling station), followed by *campo sujo* (n=40; 13 sampling stations), *tabocal* (n=17; three sampling stations) and *mata de galeria* (n=1; three sampling station). Most individuals were recorded during the rainy season (56%; n=300; seven months) and 236 individuals (44%) were recorded during the dry season (four months).

The forward selection of models including variables pertaining to phytophysiognomies resulted in the comparison of seven models. The ΔAICc of these models ranged from 0 to 68.1 and the explained variance ranged from 5.2% to 0%. The best model in this category included the variables phytophysiognomies (fito) and distance to Cerrado (distcerrado), and explained 5.2% of the variation in the local distribution data.

The forward selection of models including variables pertaining to meteorological category ranged the best values after the comparison of 11 models. The ΔAICc of these models ranged from 0 to 122,2 and the explained variance ranged from 9,2% to 0,2%. The best model included descriptors composed by maximum temperature of the months (TmaxSa), minimum temperature of the months (TminMo), minimum temperature of the sampling (TminSa) and precipitation of the sampling (PreSa), and explained 9,2% of the variation in the local distribution data.

The forward selection of models including variables pertaining to seasonal resulted in the comparison of two models. The ΔAICc of these models ranged from 0 to 131 and the explained deviance ranged from 9,7% to 0,9%. The best model in this category included months variables, and explained 9,7% of the variation in the local distribution data.

The forward selection of models including variables pertaining to microhabitat resulted in the comparison of 45 models. The ΔAICc of these models ranged from 0 to 46,1 and the explained variance ranged from 4% to 0%. The best model in this category included the microhabitat variables trees, stems, shrubs, leaf litter and canopy, and explained 5.2% of the variation in the local distribution data.

The last group of descriptor analysed is the climatological represented by climatic patters (NC). The forward selection of models including variables pertaining to Climatological (climatic patters) resulted in the comparison of nine models. The ΔAICc of these models ranged from 1436,4 to 1331,1 and the explained variance ranged from 7,8% to 0,1%. The best model in this category included the Climatological variables Insolation, precipitation and medium temperature (InsulNC), (PreNC), (TmedNC), and explained 7,8% of the variation in the local distribution data.

Among best generated models, the seasonal and meteorological reached the highest explained deviances (Table IV).

Table VII. Best tested models for each category with environmental variables and information about each category; K: number of parameters in the model; AICc corrected Akaike information criterion; ΔAIC: difference to the smallest AICc value. Environmental descriptor with significant effect on each of the best model: p<0,05 (*); p<0.01(**); p<0.001 (***).

Best Models	K	AICc	ΔAICc	% explained deviance
Phytophysiognomies				
(-) Cs, (-) Mt**, (-) Ta*, (-) distcerrado***	4	1370,2	76.1	5,2%
Meteorological				
*(+) TmaxSa ***, (+) TminMo***, (-) TminSa ***, (-) PreSa***	6	1313,9	19.8	9,2%
Seasonal				
Month (+) August***, (+) December ***. (+) February**, (+) June***, (+)May***, (+) October***	4	1294,1	0	9,7%
Microhabitat				
*(-) trees***, (+) stems***, (+) shrubs***, (+) leaflitter**, (-) canopy**	7	1391,0	0	4%
Climatological				
*(-) InsulNC***, (+) PreNC, (+) TmedNC***	5	1331,1	37.0	7,8%

3.5. Discussion

The seasonal (9,7%), meteorological (9,2%) and climatological models (7,8%) acted more intensely to explain the local distribution of *T. oreadicus* within the gradient presenting the highest explained deviance between the all categories. The seasonal category seems to be the strongest model to explain the distribution of *T. oreadicus* due the highest explained deviance and lower ΔAICc. Moreover, the categories *phytophysiognomies* (5,2%) and *microhabitat* (4%) were also correlated with the local distribution of this species. Perhaps, in response to heterogeneity of Cerrado habitat, the various environmental variables influence the local distribution of species in the Cerrado, and therefore all models presented substantial explained the variation of the local distribution of *T. oreadicus*.

3.5.1. Phytophysionomical effect

In the inventory, we registered the species *T. oreadicus* in all phytophysiognomies. The genus T*ropidurus* presents a larger flexibility in ecological traits (Mesquita et al., 2007) and some ecomorphological divergence is a way of coexisting in a heterogeneous landscape (Faria and Araujo, 2004).

The best model including phytophysionomical variables explained 5,2% of the variation in the local distribution data, included the categorical variables phytophysiognomies and the distance of the phytophysiognomies. The variable distance of *campo sujo (distsujo), tabocal (disttabocal)* and *mata de galeria (distmata)* were negatively correlated with the response variable (*cerrado sensu stricuto*), corroborating the preference of *T. oreadicus* for open areas of Cerrado, where the distance from *cerrado sensu stricto* can contribute negatively the presence of this specie in the gradient. As reported by Colli, et al (1992), *T. oreadicus* is very common in open vegetation, but was absent from *mata de galeria.* Similarly, we recorded only one *T. oreadicus* in *mata de galeria* (3 sampling station).

3.5.2. Meteorological and seasonal influence

The models that better explained the distribution of *T. oreadicus* were meteorological (9,2%) and seasonal models (9,7%). With the seasonal model the months October, December, February, Mai, June and August were positively correlated with the distribution of *T. oreadicus*. Although the dry season explain positively the distribution, the month of dry and rainy season that are also positively correlated, with the distribution are equivalent (three months of dry season and three of rainy season). Is possible that part of the distribution of *T. oreadicus* during the rainy season is promoted by the seasonal reproduction (Meira, 2007)

Several studies suggest that tropical ectotherms are more vulnerable to warming temperatures than ectotherm species farther from the equator (e.g., Deutsch et al., 2008; Sinervo et al., 2010; Huey et al., 2012) and lizards may shift their range location and size in response to seasonal and climatic change, variations in habitat productivity, distribution or lizard density, and reproductive factors such as breeding season (Sheldahl and Martins 2000, Wone and Beauchamp 2003, Kerr and Bull, 2006). Lizards must meet their thermoregulatory needs to perform their activities with strict relation with the temperature (Novaes-e-Silva and Araújo 2008) and several environmental features can influence life cycle patterns, such as temperature, precipitation and sunlight period (Censky, 1995).

3.5.3. Microhabitat influence

The microhabitat model showed as best combination the environmental variables *trees, stems, shrubs, leaflitter* and *canopy* explaining 4% of the distribution of *T. oreadicus*. Environmental factor as number of trees, stems, shrubs and leaf litter are variables most found in savanna and open-grass areas (Ribeiro and Walter, 1998) such as in *cerrado sensu stricto* and *campo sujo* (phytophysiognomies with less woody species). Phytophysiognomies with large density of canopy and number of trees such as *mata de galeria*, seems act as a negative factor related to the distribution of *T. oreadicus,* where we recorded a low number of *T. oreadicus* in this phytophysiognomies (n=1) corroborating the findings of Colli, et al., (1992). Microhabitat as termites, logs and rocks are important microhabitat for *T. oreadicus* (Meira et al., 2007, Faria and Araujo, 2004) but in our ecological modelling these microhabitat didn´t explain enough the local distribution.

3.5.4. Climatological influence

Long-term temperature or climatic variation play an important role in the selection process in the evolution of living beings and is often driver of evolutionary change and biodiversity (Erwin, 2009). The current climate is important for the local distribution, but the climatic stability is a better predictor of squamate species distribution in the Brazilian Cerrado. The ecological modelling with the climatological category showed as an important factor on the local distribution of *T. oreadicus* where temperature, precipitation, insolation explained 7,8% of the presence of this lizards. The *normais climáticas* (climatological normal) can explain filogeographic factor of long term variation, creating ecological affinities and adaptations of this species in their habitat and microhabitat in the Cerrado biome.

The climatological models study with a tropical-lizards species present in the Cerrado biome (*K. calcarata*), indicate that this is species are at high risk of local extinction caused by increasing temperatures (Silva et al., 2018). Therefore, seasonal changes in long-term in Cerrado areas can promote extinctions on tropical lizard. Another study that try to understand the conservation of Cerrado tree species in the face of climate change, indicate a predicted decline by more than 90% in potential distributional area in the Cerrado region (Siqueira and Peterson, 2003). In addition to the impacts related to the Cerrado, climate change is a strong change factor, increasing the potential of biodiversity loss in the Cerrado biome.

Chapter IV

4. FINAL DISCUSSION

The Cerrado biome has a high importance related to the ecological health in Brazil due the economic importance, water resources and biodiversity. Several anthropogenic factors of change in the Cerrado has threatened the conservation of this biome (Klink and Machado, 2005). Beyond all the known threats to the Cerrado biome of last decades, in recent years, new areas has been replaced by soybean cops through the new economic project called MATOPIBA, putting in greater threat the few natural areas that remain in this biome, mainly in the North and Northeast.

It is urgent to propose new studies in the Cerrado areas as a way to provide knowledge and insights for the conservation and protection of the habitats and the herpetological communities, mainly in the northern region (Diniz-Filho et al., 2005). As observed in our study, the herpetofauna in Cerrado biome is formed by a complex of species with high species richness and communities strongly associated to specific microhabitats (Gainsbury & Colli 2003; Mesquita et al. 2006, Bastos, 2007, Brandão & Araújo 2001) unevenly distributed in a heterogeneous habitat (Colli et al, 2002, Nogueira et al. 2005, Nogueira, 2009). Apparently, the seasonal, meteorological and climatological factors are still more consistent factors in determining the local distribution, since anurans and lizards are ectotherms. The majority of anurans species present reproductive activity during the rainy season, with abundancies influenced by rain and temperatures (Bastos, 2007), whereas lizards must meet their thermoregulatory needs to perform their activities with strict relation with the temperature (Novaes-e-Silva & Araújo 2008).

Keep the heterogeneity of vegetation in Cerrado areas would ensure that the niches of each species are kept in their area (Campos et al., 2013), protecting the species and maintaining ecosystem services. The sampled region presented a high richness of species corroborated by other studies in the Cerrado biome with an assemblage composed by widely species, species shared by others biomes and endemic species, in which the heterogeneity maintain the diversity of species with different ecological requirements in the cerrado gradient. We registered a composition with a greater amount of species shared with Caatinga, similarly as other studies performed in the North-central of the biome (Nogueira, 2011; Valdugo, 2011; Recoder, 2011, Vitt et al., 2002), that may be due the proximity from Caatinga biome.

The Brazilian forest code (law nº 7.803, 18/07/1989) legislate for the protection of riparian areas that are classified as Permanent Preservation Area (APP) without attention to the mosaic of vegetation in the Cerrado biome. Therefore, not only the forest environments, but mainly open areas are important for the maintenance of species in the Cerrado biome (Nogueira et al., 2009). Thus, this study increases the knowledge about the herpetofauna in a northern-central area of Cerrado, showing the importance of the heterogeneity of vegetation for the conservation of species in the Cerrado biome. To understand the dynamics of species and the effect of the environmental variables, there are ways to provide information to support decisions about the protection of Cerrado species as well as their landscape and environmental services.

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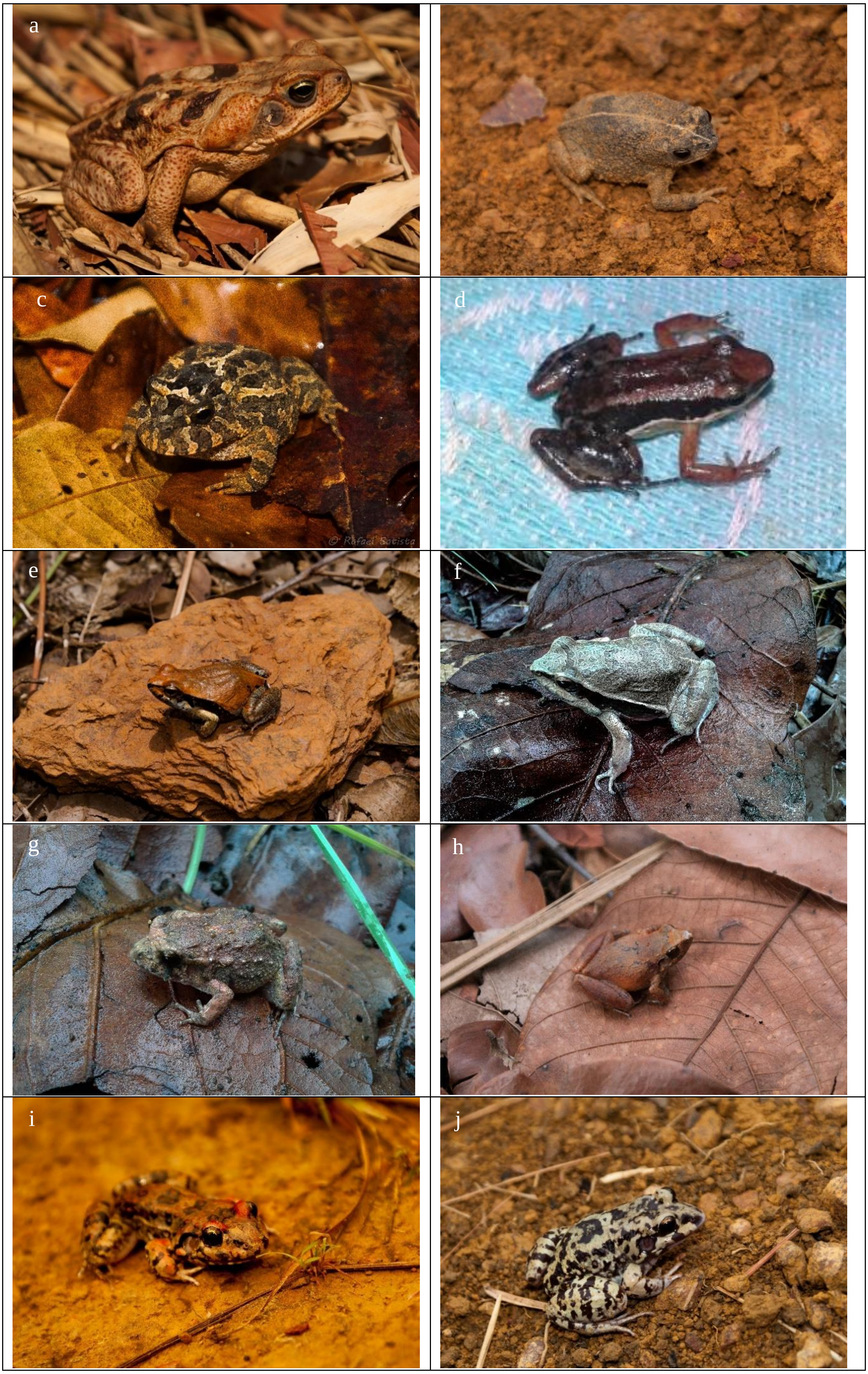
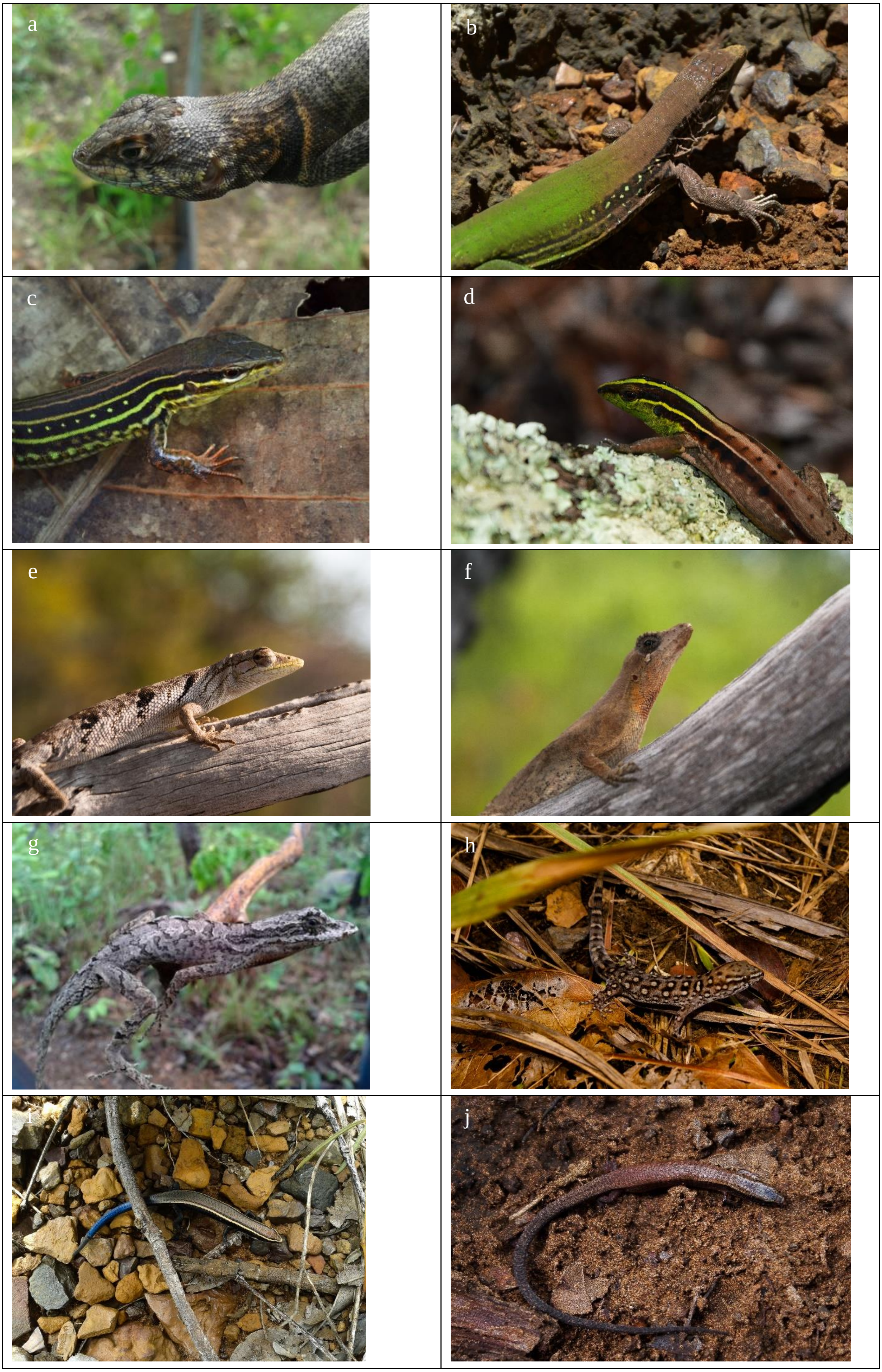
VI. Appendices

Plates I. Anurans recorded in Fazenda Ecológica, Taquaruçu, Palmas, Tocantins, Brazil.



Plates I. Anuran species recorded in Fazenda Ecológica, Palmas, Taquaruçu, Tocantins, Brazil. (a) *Rhinella schneideri*; (b) *Rhinella granulosa*; (c)*Proceratophrys branti*; (d)*Allobates crombiei;* (e) *Physalaemus cuvieri;* (f) *Physalaemus centralis;* (g) *Adenomera* sp.*;* (h) *Barycholos ternetzi;* (i) *Leptodactylus syphax;* (j) *Leptodactylus troglodytes;* (l) *Chiasmocleis albopunctata;* (m) *Leptodactylus fuscus;* (n) *Leptodactylus labyrinthicus;* (o) *Elachistocleis cesarii;* (o) *Bokermannohyla pseudopseudis.*

Plates II. Lizards recorded in Fazenda Ecológica, Taquaruçu, Palmas, Tocantins, Brazil.



Plates II. Lizard species recorded in Fazenda Ecológica, Palmas, Taquaruçu, Tocantins, Brazil. (a)*Tropidurus oreadicus;* (b)*Ameiva ameiva ameiva;* (c)*Ameivula ocellifera;* (d)*Kentropyx calcarata;* (e)*Polychrus acutirostris;* (f)*Norops brasiliensis;* (g) *Norops meridionalis;* (h)*Gymnodactylus geckoides;* (i)*Micrablepharus maximiliani;* (j)*Colobosaura modesta;* (l)*Copeoglossum nigropunctatum;* (m)*Notomabuya frenata;* (n)*Cercosaura ocellata;* (o)*Tupinambis quadrilineatus.*

Appendix III. Coordinates pitfall trap from study area

Table V. Coordinates pitfall trap from study area		
Pitfalls	**Phytophysiognomies**	**Coordinates**
1	Campo sujo	S10° 15.995' W48° 08.695'
2	Campo sujo	S10° 16.016' W48° 08.712'
3	Campo sujo	S10° 16.034' W48° 08.727'
4	Campo sujo	S10° 16.053' W48° 08.757'
5	Campo sujo	S10° 16.060' W48° 08.785'
6	Campo sujo	S10° 16.074' W48° 08.811'
7	Campo sujo	S10° 16.064' W48° 08.837'
8	Campo sujo	S10° 16.069' W48° 08.858'
9	Campo sujo	S10° 16.078' W48° 08.884'
10	Campo sujo	S10° 16.098' W48° 08.915'
11	Campo sujo	S10° 16.089' W48° 08.943'
12	Cerrado sensu stricto	S10° 16.078' W48° 08.971'
13	Cerrado sensu stricto	S10° 16.089' W48° 09.007'
14	Cerrado sensu stricto	S10° 16.095' W48° 09.031'
15	Cerrado sensu stricto	S10° 16.080' W48° 09.053'
16	Cerrado sensu stricto	S10° 16.081' W48° 09.079'
17	Cerrado sensu stricto	S10° 16.077' W48° 09.102'
18	Cerrado sensu stricto	S10° 16.070' W48° 09.126'
19	Cerrado sensu stricto	S10° 16.067' W48° 09.152'
20	Cerrado sensu stricto	S10° 16.061' W48° 09.173'
21	Tabocal	S10° 16.067' W48° 09.198'
22	Tabocal	S10° 16.068' W48° 09.217'
23	Mata de Galeria	S10° 16.088' W48° 09.248'
24	Mata de Galeria	S10° 16.105' W48° 09.255'
25	Mata de Galeria	S10° 16.125' W48° 09.234'
26	Tabocal	S10° 16.156' W48° 09.238'
27	Cerrado sensu stricto	S10° 16.199' W48° 09.241'
28	Cerrado sensu stricto	S10° 16.216' W48° 09.264'
29	Cerrado sensu stricto	S10° 16.198' W48° 09.284'
30	Cerrado sensu stricto	S10° 16.183' W48° 09.310'
31	Cerrado sensu stricto	S10° 16.200' W48° 09.339'
32	Cerrado sensu stricto	S10° 16.225' W48° 09.374'
33	Cerrado sensu stricto	S10° 16.223' W48° 09.396'
34	Cerrado sensu stricto	S10° 16.255' W48° 09.404'
35	Cerrado sensu stricto	S10° 16.276' W48° 09.415'
36	Cerrado sensu stricto	S10° 16.295' W48° 09.428'
37	Campo sujo	S10° 16.315' W48° 09.447'
38	Campo sujo	S10° 16.300' W48° 09.476'
39	Cerrado sensu stricto	S10° 16.270' W48° 09.479'
40	Cerrado sensu stricto	S10° 16.252' W48° 09.479'
41	Cerrado sensu stricto	S10° 16.241' W48° 09.488'
42	Cerrado sensu stricto	S10° 16.224' W48° 09.512'
43	Cerrado sensu stricto	S10° 16.239' W48° 09.530'
44	Cerrado sensu stricto	S10° 16.268' W48° 09.536'
45	Cerrado sensu stricto	S10° 16.295' W48° 09.542'
46	Cerrado sensu stricto	S10° 16.303' W48° 09.566'
47	Cerrado sensu stricto	S10° 16.299' W48° 09.611'
48	Cerrado sensu stricto	S10° 16.300' W48° 09.644'
49	Cerrado sensu stricto	S10° 16.295' W48° 09.684'

Appendix IV. Figure VI. Fauna License provide by ICMBio and MMA, Brazil. (Authorization for activities with scientific purposes)

Ministério do Meio Ambiente - MMA
Instituto Chico Mendes de Conservação da Biodiversidade - ICMBio
Sistema de Autorização e Informação em Biodiversidade - SISBIO

Autorização para atividades com finalidade científica

Número: 40970-1	Data da Emissão: 09/10/2013 08:00	Data para Revalidação*: 08/11/2014
* De acordo com o art. 33 da IN 154/2009, esta autorização tem prazo de validade equivalente ao previsto no cronograma de atividades do projeto, mas deverá ser revalidada anualmente mediante a apresentação do relatório de atividades a ser enviado por meio do Sisbio no prazo de até 30 dias a contar da data do aniversário de sua emissão.		

Dados do titular

Nome: Rafael Batista de Mendonça	CPF: 003.190.281-27
Título do Projeto: Efeito de variáveis ambientais sobre comunidades de lagartos em diferentes fitofisionomias de Cerrado.	
Nome da Instituição : FUNDAÇÃO UNIVERSIDADE DE BRASÍLIA	CNPJ: 00.038.174/0001-43

Cronograma de atividades

#	Descrição da atividade	Início (mês/ano)	Fim (mês/ano)
1	Amostragem de lagartos	09/2013	09/2014

Observações e ressalvas

1	As atividades de campo exercidas por pessoa natural ou jurídica estrangeira, em todo o território nacional, que impliquem o deslocamento de recursos humanos e materiais, tendo por objeto coletar dados, materiais, espécimes biológicos e minerais, peças integrantes da cultura nativa e cultura popular, presente e passada, obtidos por meio de recursos e técnicas que se destinem ao estudo, à difusão ou à pesquisa, estão sujeitas a autorização do Ministério de Ciência e Tecnologia.
2	Esta autorização NÃO exime o pesquisador titular e os membros de sua equipe da necessidade de obter as anuências previstas em outros instrumentos legais, bem como do consentimento do responsável pela área, pública ou privada, onde será realizada a atividade, inclusive do órgão gestor de terra indígena (FUNAI), da unidade de conservação estadual, distrital ou municipal, ou do proprietário, arrendatário, posseiro ou morador de área dentro dos limites de unidade de conservação federal cujo processo de regularização fundiária encontra-se em curso.
3	Este documento somente poderá ser utilizado para os fins previstos na Instrução Normativa IBAMA nº 154/2007 ou na Instrução Normativa ICMBio nº 10/2010, no que especifica esta Autorização, não podendo ser utilizado para fins comerciais, industriais ou esportivos. O material biológico coletado deverá ser utilizado para atividades científicas ou didáticas no âmbito do ensino superior.
4	A autorização para envio ao exterior de material biológico não consignado deverá ser requerida por meio do endereço eletrônico www.ibama.gov.br (Serviços on-line - Licença para importação ou exportação de flora e fauna - CITES e não CITES).
5	O titular de licença ou autorização e os membros da sua equipe deverão optar por métodos de coleta e instrumentos de captura direcionados, sempre que possível, ao grupo taxonômico de interesse, evitando a morte ou dano significativo a outros grupos; e empregar esforço de coleta ou captura que não comprometa a viabilidade de populações do grupo taxonômico de interesse em condição in situ.
6	O titular de autorização ou de licença permanente, assim como os membros de sua equipe, quando da violação da legislação vigente, ou quando da inadequação, omissão ou falsa descrição de informações relevantes que subsidiaram a expedição do ato, poderá, mediante decisão motivada, ter a autorização ou licença suspensa ou revogada pelo ICMBio e o material biológico coletado apreendido nos termos da legislação brasileira em vigor.
7	Este documento não dispensa o cumprimento da legislação que dispõe sobre acesso a componente do patrimônio genético existente no território nacional, na plataforma continental e na zona econômica exclusiva, ou ao conhecimento tradicional associado ao patrimônio genético, para fins de pesquisa científica, bioprospecção e desenvolvimento tecnológico. Veja maiores informações em www.mma.gov.br/cgen.
8	Em caso de pesquisa em UNIDADE DE CONSERVAÇÃO, o pesquisador titular desta autorização deverá contactar a administração da unidade a fim de CONFIRMAR AS DATAS das expedições, as condições para realização das coletas e de uso da infra-estrutura da unidade.

Outras ressalvas

1	1-Recomendamos a utilização de outro método de marcação que seja alternativo à ablação de artelhos, desde que o mesmo ocasione injúrias menores ao animal; Caso a ablação de artelho seja o único método possível, dentro do escopo do projeto e tendo em vista as características da espécie-alvo, recomendamos que, como meio de minimizar eventual injúria e/ou infecção, seja feita a dessensibilização e a anestesia do local do corte, com xilocaína, e, se possível, que a ferida cirúrgica seja isolada com fio de sutura absorvível. 2)Para o sacrifício dos animais, recomendamos o uso de método que não caracterize maus-tratos, como, por exemplo, os métodos preconizado na Resolução nº 301/2012-CFBio ou da Resolução nº 1000/2012-CFMV.4 Pesquisador deve informar a formação profissional no curriculum lattes

Locais onde as atividades de campo serão executadas

#	Município	UF	Descrição do local	Tipo
1	PALMAS	TO	Fazenda Ecológica - Taquaruçu - Tocantins	Fora de UC Federal

Atividades X Táxons

#	Atividade	Táxons

Este documento (Autorização para atividades com finalidade científica) foi expedido com base na Instrução Normativa nº154/2007. Através do código de autenticação abaixo, qualquer cidadão poderá verificar a autenticidade ou regularidade deste documento, por meio da página do Sisbio/ICMBio na Internet (www.icmbio.gov.br/sisbio).

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Nome da Instituição : FUNDAÇÃO UNIVERSIDADE DE BRASÍLIA	CNPJ: 00.038.174/0001-43

Registro de coleta imprevista de material biológico

De acordo com a Instrução Normativa nº154/2007, a coleta imprevista de material biológico ou de substrato não contemplado na autorização ou na licença permanente deverá ser anotada na mesma, em campo específico, por ocasião da coleta, devendo esta coleta imprevista ser comunicada por meio do relatório de atividades. O transporte do material biológico ou do substrato deverá ser acompanhado da autorização ou da licença permanente com a devida anotação. O material biológico coletado de forma imprevista, deverá ser destinado à instituição científica e, depositado, preferencialmente, em coleção biológica científica registrada no Cadastro Nacional de Coleções Biológicas (CCBIO).

Táxon*	Qtde.	Tipo de amostra	Qtde.	Data

* Identificar o espécime no nível taxonômico possível.

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1	Captura de animais silvestres in situ	Squamata
2	Coleta/transporte de amostras biológicas in situ	Squamata
3	Coleta/transporte de espécimes da fauna silvestre in situ	Squamata (*Qtde: 2)
4	Marcação de animais silvestres in situ	Squamata

* Quantidade de indivíduos por espécie, por localidade ou unidade de conservação, a serem coletados durante um ano.

Material e métodos

1	Amostras biológicas (Répteis)	Outras amostras biológicas(Artelho)
2	Método de captura/coleta (Répteis)	Armadilha de queda "pit fall"
3	Método de marcação (Répteis)	Outros métodos de marcação(Corte de artelhos)

Destino do material biológico coletado

#	Nome local destino	Tipo Destino
1	FUNDAÇÃO UNIVERSIDADE DE BRASÍLIA	coleção

Este documento (Autorização para atividades com finalidade científica) foi expedido com base na Instrução Normativa nº154/2007. Através do código de autenticação abaixo, qualquer cidadão poderá verificar a autenticidade ou regularidade deste documento, por meio da página do Sisbio/ICMBio na Internet (www.icmbio.gov.br/sisbio).

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Appendix V. Environmental variables (GLMM)

Table VII. Tested models for each category with environmental variables and information about each category: K: number of parameters in the model; AICc corrected Akaike information criterium; ΔAIC: diference to the smallest AICc value; wi: weight of model in the set of partial models. Best models are in each category are highlighted in dark grey;

	Model (environmental descriptor)	K	AICc	DeltaAICc	Wi	Deviance	% explained devince
Phytophysiognomies	Fito + distcerrado	4	1370,2	0,0	0,59	1357,5	5,2%
	Fito + distsujo	4	1377,7	7,5	0,01	1365	4,7%
	Fito	3	1375,1	1375,5	0,04	1365,1	4,7%
	distcerrado	3	1387,7	17,5	0,00	1381,3	3,5%
	distsujo	3	1438,0	67,8	0,00	1431,6	0,0%
	disttabocal	3	1438,3	68,1	0,00	1431,9	0,0%

	Model (environmental descriptor)	K	AICc	DeltaAICc	Wi	Deviance	% explained devince
Meteorological	TmaxSa + TminMo + TminSa + PreSa	6	1313,9	0,0	0,93	1300,3	9,2%
	TmaxSa + TminMo + TminSa	5	1319,2	5,3	0,00	1308,1	8,6%
	TmaxSa + TminMo + PreSa	5	1325,3	11,4	0,00	1314,2	8,2%
	TmaxSa + TminMo	4	1327,2	13,3	0,00	1318,5	7,9%
	TmaxSa + TminSa	4	1333,3	19,4	0,00	1324,6	7,5%
	TmaxSa + PreSa	4	1332,7	18,8	0,00	1324,0	7,5%
	TmaxSa	3	1331,4	17,5	0,00	1325,0	7,5%
	PreSa	3	1392,4	78,5	0,00	1386,0	3,2%
	TminMo	3	1401,0	87,1	0,00	1394,6	2,6%
	TminSa	3	1435,7	121,8	0,00	1429,3	0,2%

	Model (environmental descriptor)	K	AICc	DeltaAICc	Wi	Deviance	% explained devince
Temporal	Month	3	1293,8	0	1,16	1293,4	9,7%
	Season	3	1425,1	131,0	0,00	1418,7	0,9%

	Model (environmental descriptor)	K	AICc	DeltaAICc	Wi	Deviance	% explained devince
Microhabitat	trees1 + stems + shrubs + leaflitter + canopy	7	1391,0	0,0	0,52	1374,8	4,0%
	trees1 + stems + shrubs + leaflitter + burrows	7	1394,7	3,7	0,08	1378,5	3,7%
	trees1 + stems + shrubs + leaflitter + herbaceous	7	1395,5	4,5	0,06	1379,3	3,7%
	trees1 + stems + shrubs + leaflitter + NTC	7	1395,2	4,2	0,06	1379	3,7%
	trees1 + stems + shrubs + leaflitter + logs	7	1396,4	5,4	0,04	1380,2	3,6%
	trees1 + stems + shrubs + leaflitter + baresoil	7	1397,5	6,5	0,02	1381,3	3,5%
	trees1 + stems + shrubs + leaflitter + termites	7	1397,5	6,5	0,02	1381,3	3,5%
	trees1 + stems + shrubs + leaflitter + NTD	7	1397,3	6,3	0,02	1381,1	3,5%
	trees1 + stems + shrubs + canopy	6	1395,0	4,0	0,07	1381,4	3,5%
	trees1 + stems + shrubs + leaflitter	6	1394,9	3,9	0,07	1381,3	3,5%
	trees1 + stems + shrubs + rocks	6	1397,4	6,4	0,02	1383,8	3,4%
	trees1 + stems + shrubs + burrows	6	1400,0	9,0	0,01	1386,4	3,2%
	trees1 + stems + shrubs + baresoil	6	1401,2	10,2	0,00	1387,6	3,1%
	trees1 + stems + shrubs + NTC	6	1401,4	10,4	0,00	1387,8	3,1%
	trees1 + stems + shrubs + herbaceus	6	1402,6	11,6	0,00	1389	3,0%
	trees1 + stems + shrubs + NTD	6	1402,3	11,3	0,00	1388,7	3,0%
	trees1 + stems + shrubs + termites	6	1402,7	11,7	0,00	1389,1	3,0%
	trees1 + stems + shrubs + logs	6	1402,5	11,5	0,00	1388,9	3,0%
	trees1 + stems + shrubs	5	1400,2	9,3	0,01	1389,1	3,0%
	trees1 + stem + canopy	5	1401,7	10,8	0,00	1390,6	2,9%
	trees1 + stems + rocks	55	1406,4	15,5	0,00	1395,3	2,6%

	trees1 + stem + leaflitter	5	1407,1	16,2	0,00	1396	2,5%
	trees1+ stems + NTC	5	1407,4	16,5	0,00	1396,3	2,5%
	trees1 + stem + baresoil	5	1409,3	18,4	0,00	1398,2	2,4%
	trees1 + stem + herbaceous	5	1410,3	19,4	0,00	1399,2	2,3%
	trees1 + stems + termites	5	1411,3	20,4	0,00	1400,2	2,2%
	trees1 + stems + logs	5	1410,8	19,9	0,00	1399,7	2,2%
	trees1 + stems + burrows	5	1411,2	20,3	0,00	1400,1	2,2%
	trees1 + stems + NTD	5	1411,8	20,9	0,00	1400,7	2,2%
	trees1 + stems	4	1409,5	18,6	0,00	1400,8	2,2%
	trees1 + canopy	4	1410,8	19,9	0,00	1402,1	2,1%
	trees1 + rocks	4	1412,6	21,7	0,00	1403,9	2,0%
	trees1 + leaflitter	4	1411,8	20,9	0,00	1403,1	2,0%
	tres1 + schubs	4	1414,0	23,1	0,00	1405,3	1,9%
	trees1+ baresoil	4	1416,3	25,4	0,00	1407,6	1,7%
	trees1 + NTC	4	1416,3	25,4	0,00	1407,6	1,7%
	trees1 + herbaceous	4	1417,7	26,8	0,00	1409	1,6%
	trees1 + burrows	4	1417,8	26,9	0,00	1409,1	1,6%
	trees1 + NTD	4	1418,2	27,3	0,00	1409,5	1,6%
	trees1 + termites	4	1418,9	28,0	0,00	1410,2	1,5%
	trees + logs	4	1418,9	28,0	0,00	1410,2	1,5%
	trees	3	1416,7	25,8	0,00	1410,3	1,5%
	leaflitter	3	1422,3	31,4	0,00	1415,9	1,1%
	rocks	3	1430,7	39,8	0,00	1424,3	0,5%
	NTD	3	1430,8	39,9	0,00	1424,4	0,5%
	baresoil	3	1433,7	42,8	0,00	1427,3	0,3%
	stems	3	1433,7	42,8	0,00	1427,3	0,3%
	logs	3	1435,5	44,6	0,00	1429,1	0,2%
	NTC	3	1435,0	44,1	0,00	1428,6	0,2%
	shrubs	3	1435,7	44,8	0,00	1429,3	0,2%
	canopy	3	1437,0	46,1	0,00	1430,6	0,1%
	burrows	3	1436,3	45,4	0,00	1429,9	0,1%
	herbaceous	3	1438,2	47,3	0,00	1431,8	0,0%
	termites	3	1438,1	47,2	0,00	1431,7	0,0%

	Model (environmental descriptor)	K	AICc	DeltaAICc	Wi	Deviance	% explained devince
Climatological	InsulNC + PreNC + TmedNC	5	1330	1331,1	0,46	1320	7,8%
	InsulNC + PreNC + TminNC	5	1330,60	1331,7	0,34	1320,6	7,8%
	InsulNC + PreNC	4	1334,6	1335,3	0,06	1326,6	7,4%
	InsulNC + TminNC	4	1357,10	1357,8	0,00	1349,1	5,8%
	InsulNC + TmedNC	4	1363,60	1364,3	0,00	1355,6	5,3%
	InsulNC	3	1364,40	1364,8	0,00	1358,4	5,1%
	TmedNC	3	1404,00	1404,4	0,00	1398	2,4%
	PreNC	3	1422,8	1423,2	0,00	1416,8	1,1%
	TminNC	3	1436,00	1436,4	0,00	1430	0,1%